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U.S. Department Of Energy
Oakland Operations Office, Oakland, California 94612

Final Closure Plan for the High-Explosives Open Burn Treatment Facility at Lawrence Livermore National Laboratory Experimental Test Site 300

April 1997

Environmental Protection Department
Operations and Regulatory Affairs Division

Lawrence Livermore National Laboratory

Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

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Chapter 1. Closure Plan

1.1 Introduction

Lawrence Livermore National Laboratory's (LLNL) Experimental Test Site 300 is located about 15 miles east of Livermore, California and 65 miles southeast of San Francisco in the sparsely populated Altamont Hills of the Diablo Range (Fig. 1.1-1). The site is operated by the University of California as an experimental test site for the U.S. Department of Energy (DOE). The site covers an area of approximately 11 square miles north of Corral Hollow Road (Fig. 1.1-2). About one-sixth of the site lies in Alameda County; the remainder is situated in San Joaquin County. The surrounding land is primarily agricultural.

Site 300 is divided into several areas: a General Service Area (GSA), located in the southeast corner of the site adjacent to Corral Hollow Road, and programmatic operation areas distributed throughout the site. The GSA contains buildings that house administrative and support functions. Programmatic operation areas include the HE Process Area for high-explosives formulation, pressing, and machining; the Weapons Test Area; and high-explosives firing areas.

The High-Explosives (HE) Open Burn Treatment Facility, Building 829 Complex, is located in the HE Process Area in the south-central portion of Site 300 (Fig. 1.1-2). The HE Open Burn Treatment Facility consists of three unlined pits and an open air burn unit that are used to thermally treat high-explosives waste. The facility is operated as a thermal treatment unit under 40 CFR, Part 265, Subpart P; and 22 CCR, Division 4.5, Chapter 15, Article 16.

This document addresses the interim status closure of the HE Open Burn Treatment Facility, as detailed by Title 22, Division 4.5, Chapter 15, Article 7 of the California Code of Regulations (CCR) and by Title 40, Code of Federal Regulations (CFR) Part 265, Subpart G, "Closure and Post Closure." The Closure Plan (Chapter 1) and the Post-Closure Plan (Chapter 2) address the concept of long-term hazard elimination. The Closure Plan provides for capping and grading the HE Open Burn Treatment Facility and revegetating the immediate area in accordance with applicable requirements. The Closure Plan also reflects careful consideration of site location and topography, geologic and hydrologic factors, climate, cover characteristics, type and amount of wastes, and the potential for contaminant migration. The Post-Closure Plan is designed to allow LLNL to monitor the movement, if any, of pollutants from the treatment area. In addition, quarterly inspections will ensure that all surfaces of the closed facility, including the cover and diversion ditches, remain in good repair, thus precluding the potential for contaminant migration.

Appendix A provides waste analysis data to support this closure. Appendix B contains the soil borehole logs and ground water monitor well logs, followed by remedial investigation soil and ground water monitoring data in Appendix C. Appendix D provides technical specifications for the cover system construction materials and methods. Project inspection methods are detailed in Appendix E, and all engineering analyses for closure are in Appendix F. Discussions of sensitivity analyses performed during the modeling effort are presented in Appendix G. Appendix H lists additional ground water and soil monitoring data. Appendix I contains the Site 300 Safety Plan for environmental restoration activities. Appendix J provides the rationale justifying a waiver of federal ground water monitoring requirements.

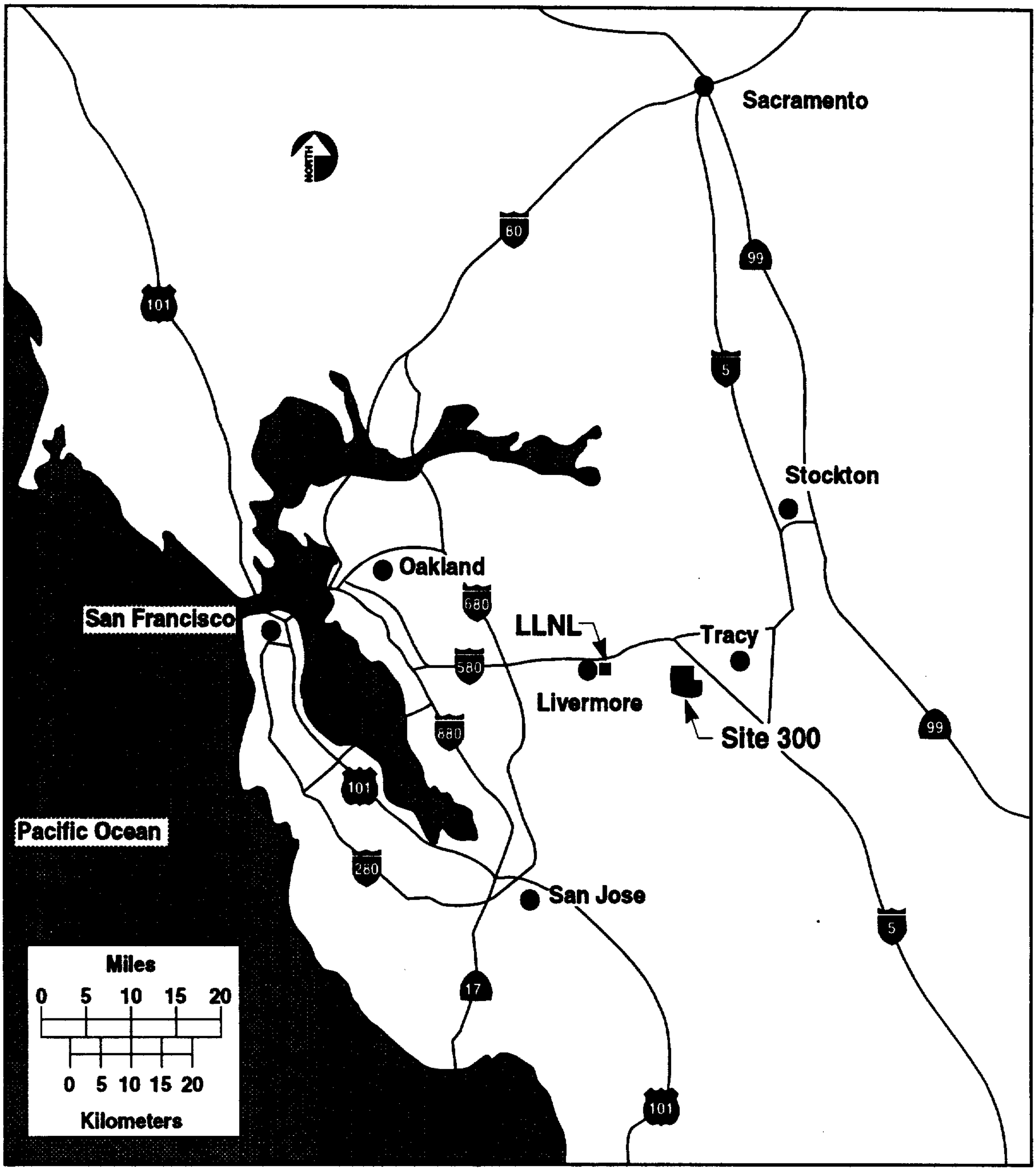

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Figure 1.1-1. Locations of LLNL Main Site and Site 300.

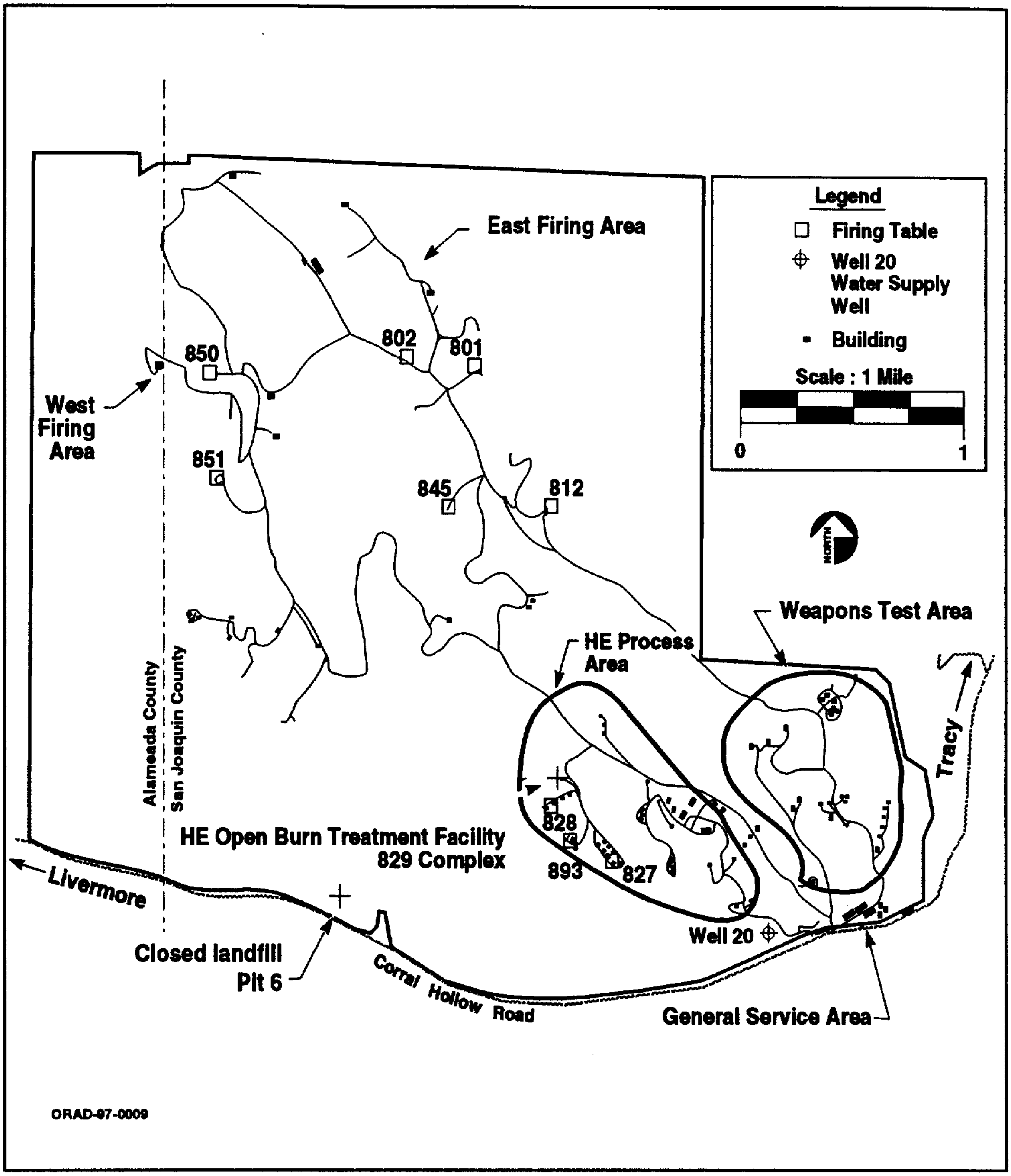

Figure 1.1-2. Site 300, general facilities map.

During closure activities, LLNL will provide monthly update reports to and coordinate any changes with the State of California Environmental Protection Agency, Department of Toxic Substances Control (DTSC); the U.S. Environmental Protection Agency (EPA); and the Central Valley Regional Water Quality Control Board (RWQCB). These three agencies will be referred to collectively as "the regulatory agencies." Before, during, and after closure and post-closure activities, LLNL will file any required notices and certifications with the appropriate agencies.

1.1.1 Facility Identification

EPA Identification Number:	CA2890090002
Name:	Lawrence Livermore National Laboratory Site 300
Type of Facility:	Experimental Test Site
Mailing Address:	Lawrence Livermore National Laboratory Site 300 P.O. Box 808, L-871 Livermore, California 94551
Location:	San Joaquin and Alameda Counties; Corral Hollow Road (7 miles west of Tracy) Tracy, CA 95376
Contact Person:	Milt Grissom, Site Manager
Telephone:	(510) 423-1396
Standard Industrial Classification (SIC) Codes:	8733, 9611
Operator Number One:	Regents, University of California Lawrence Livermore National Laboratory P.O. Box 808, L-626 Livermore, California 94551
Contact Person:	Harry L. Galles, Department Head Environmental Protection Department
Telephone:	(510) 423-7983
Operator Number Two and Owner:	United States Government U.S. Department of Energy San Francisco Operations Office 1333 Broadway Oakland, California 94612
Contact Person:	James T. Davis, Assistant Manager for Environmental Management and Support
Telephone:	(510) 273-6440
LLNL Plan Contact Person:	C. Susi Jackson, Division Leader Operations and Regulatory Affairs Division Environmental Protection Department Lawrence Livermore National Laboratory P.O. Box 808, L-633 Livermore, California 94551
Telephone:	(510) 423-6577

1.1.2 Financial Requirements

Site 300 is a U.S. Government facility and is exempt from the financial requirements in 40 CFR 265.140(c) Subpart H and the corresponding section of Title 22, Division 4.5, Chapter 15, Article 8 of the California Code of Regulations.

1.1.3 Amending the Closure Plan [22 CCR 66265.112(c) and 40 CFR 265.112(c)]

LLNL will amend the closure plan whenever changes in the operating plans or facility design occur, or when unexpected events require a modification during closure activities. Requests for modifications to the closure plan will be made within 60 days after any unforeseen changes occur or at least 60 days prior to any proposed changes in operations or events that affect this plan.

1.1.4 Certifications

1.1.4.1 Certification of Closure [22 CCR 66265.115 and 40 CFR 265.115]

Within 60 days following the completion of closure activities, LLNL will submit certification to the DTSC signed by both LLNL and an independent professional engineer registered in the State of California that the HE Open Burn Treatment Facility has been closed in accordance with the approved Closure Plan.

A copy of the approved Closure Plan and subsequent amendments will be maintained at each of the following locations:

- Site 300 Resident Manager
  Corral Hollow Road
  Tracy, California 95376
- Lawrence Livermore National Laboratory
  Environmental Protection Department
  7000 East Avenue
  Livermore, California 94551
- Department of Energy
  San Francisco Field Office
  Livermore Site Office
  7000 East Ave.
  Livermore, California 94550

1.1.4.2 Submission of Survey Plat [22 CCR 66265.116 and 40 CFR 265.116]

No later than the closure certification date, LLNL will submit to the DTSC and file with local land use and/or zoning authorities, a survey plat of the closed HE Open Burn Treatment Facility. The survey plat will indicate the locations and dimensions of the facility with respect to permanently surveyed benchmarks. The plat will be prepared by a registered land surveyor and will contain the required notices concerning disturbance issues.

1.2 Facility Description

1.2.1 Topography and Climate

The topography of Site 300 is characterized by steep hills and rugged canyons. In the northern portion, roughly north of Building 850, the surface water flows primarily in a northeasterly direction (Fig. 1.2-1). South of Building 850, the surface water flows in a south to southeasterly direction toward Corral Hollow Road. The area around Site 300 is sparsely populated and used primarily for agriculture.

The HE Open Burn Treatment Facility is located in the south-central portion of Site 300, approximately 4,500 ft north of the nearest Site 300 fence line. The HE Open Burn Treatment Facility is located on the nose of a ridge overlooking a steep-sided ravine to the southwest. The facility is over 400 ft above Corral Hollow Creek and well outside the 100-year storm flood line. Except for Building Complexes 828 and 829, land within 1,000 ft in any direction of the HE Open Burn Treatment Facility is open space.

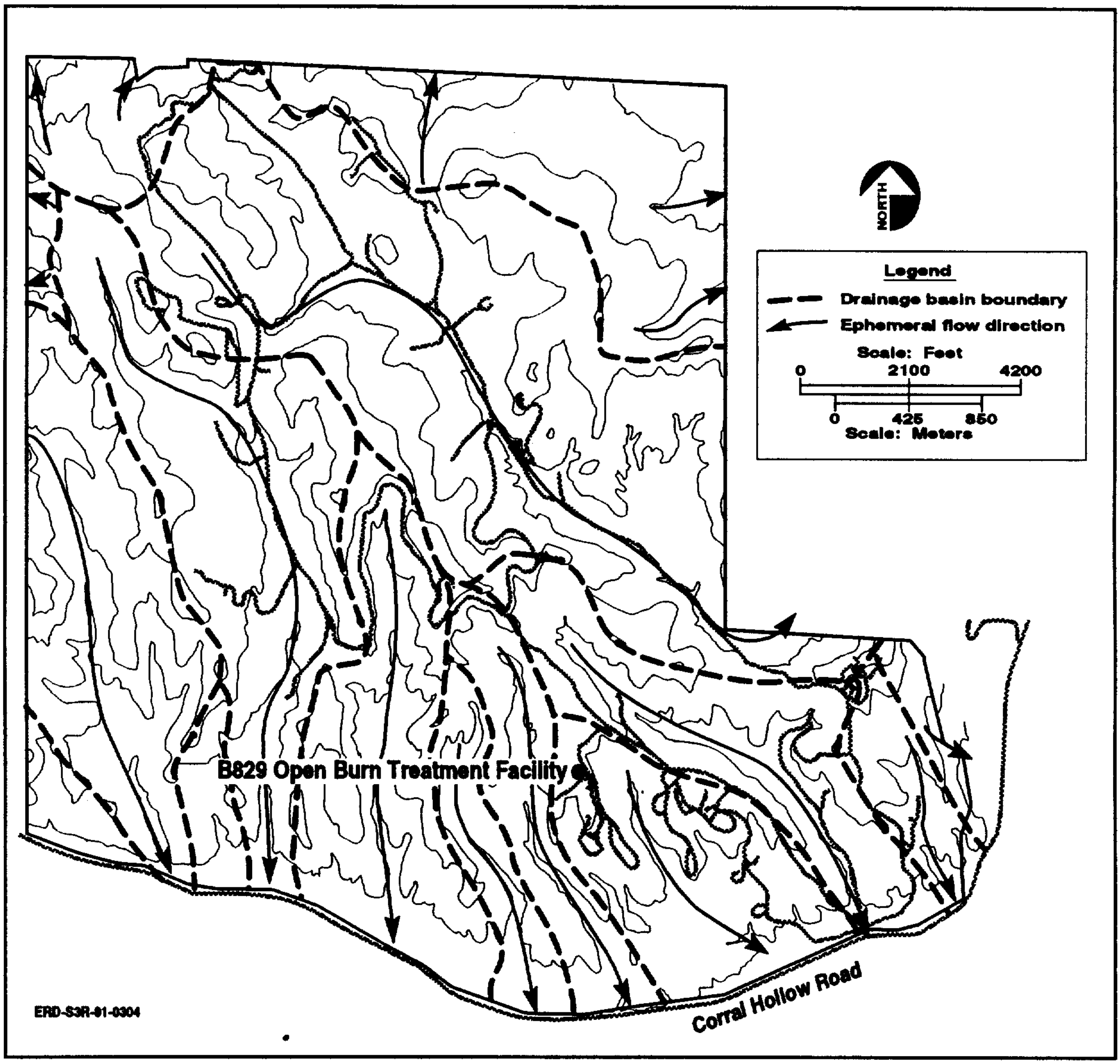

Figure 1.2-1. Site 300 map showing drainage basins and general direction of ephemeral surface water flow.

The climate of Site 300 is generally characterized by mild winters with low rainfall and hot, dry summers. Sunshine is abundant throughout the year. Based on data collected at the Site 300 weather station from 1965 to 1975, the average annual rainfall was 11.39 in. For the 15-year period from 1973 through 1987, the average rainfall was 10.87 in., with a maximum of 21.16 in. during 1983 and a minimum of 5.81 in. during the drought year 1976. Rainfall for the years 1988, 1989, and 1990, a drought period, was 6.04 , 5.43 , and 6.71 in., respectively. Figure 1.2-2 shows rainfall data from January 1983 through July 31, 1996. Mean daily temperatures for the years 1976–1989 ranged from 60 to 66°F. A combination of warm temperatures and generally windy conditions at Site 300 results in a significant rate of evapotranspiration.

Figure 1.2-3 is a wind rose that depicts average data on annual wind direction and speed for Site 300 (Sims *et al.*, 1990). As shown, the predominant wind direction is from the west-southwest. Data were collected at the Site 300 weather station at a height of 32.8 ft (10 m) on the meteorological tower. These data are consistent with wind patterns observed in prior years.

1.2.2 HE Open Burn Treatment Facility

The HE Open Burn Treatment Facility, part of the Building 829 Complex located at Site 300, is used to thermally treat explosives process waste generated by operations in the HE Process Area and from explosives research operations at the LLNL Livermore main site. The facility was constructed in 1955 and consists of three separate burn pits and an open air burn unit also known as the "Iron Horse" (Fig. 1.2-4).

The burn area was constructed on a flat surface created by cutting and filling bedrock along the nose of a ridge formed on three sides by steep slopes of the natural drainage system. The burn pits were excavated 3 to 4 ft into the graded, level pad (Fig. 1.2-4). Each pit is approximately 20 ft wide at the bottom and 30 ft long with sloping sides except for Pit 3, which has a sloping ramp approximately 35 ft long. The walls of Burn Pits 1 and 2 are fill material. At least one wall of Burn Pit 3 is also fill material. The bottoms of Pits 1 and 2 are within 1 to 2 ft of bedrock and the bottom of Pit 3 is bedrock. All of the pits are unlined. The earth-filled portion of the burn pits has not been compacted other than the compaction received from the bulldozer during construction and from settlement over time resulting from the weight of the fill material.

Only explosives wastes are treated at the HE Open Burn Treatment Facility. Explosives and explosives-contaminated wastes are generated from explosives formulation, detonation testing on the firing tables, and from the manufacturing process. The wastes include pieces of undetonated explosives, miscellaneous burnable materials that are judged to be contaminated with explosives, and fines collected in clarifiers from explosive materials machining. Since the facility opened, four different treatment procedures for explosives wastes were used. These procedures are described below.

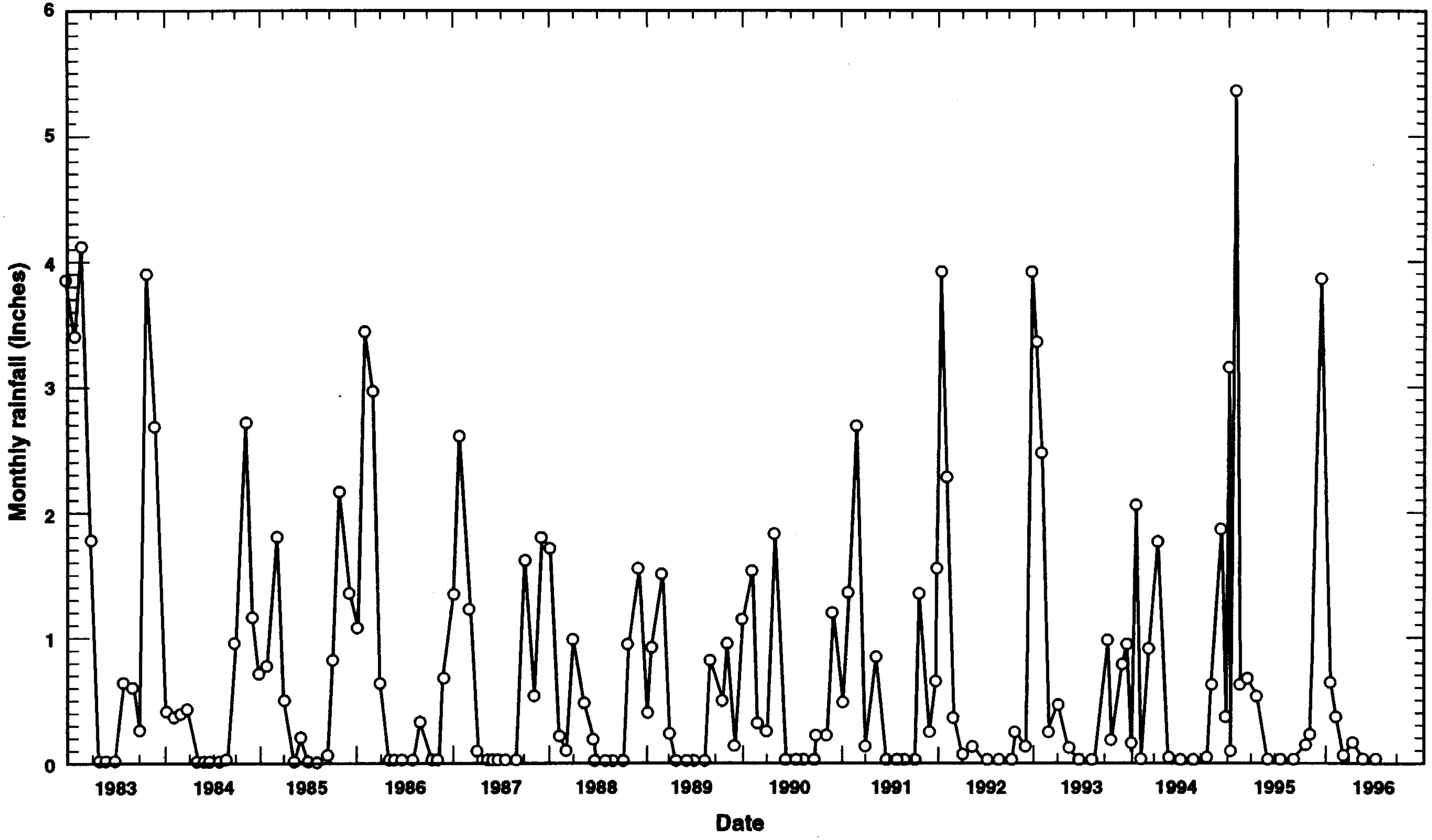

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Figure 1.2-2. Monthly rainfall for Site 300 from January 1, 1983 to July 31, 1996 at the Building 848 Meteorological Station, located approximately 0.9 mile northeast of the Open Burn Treatment Facility.

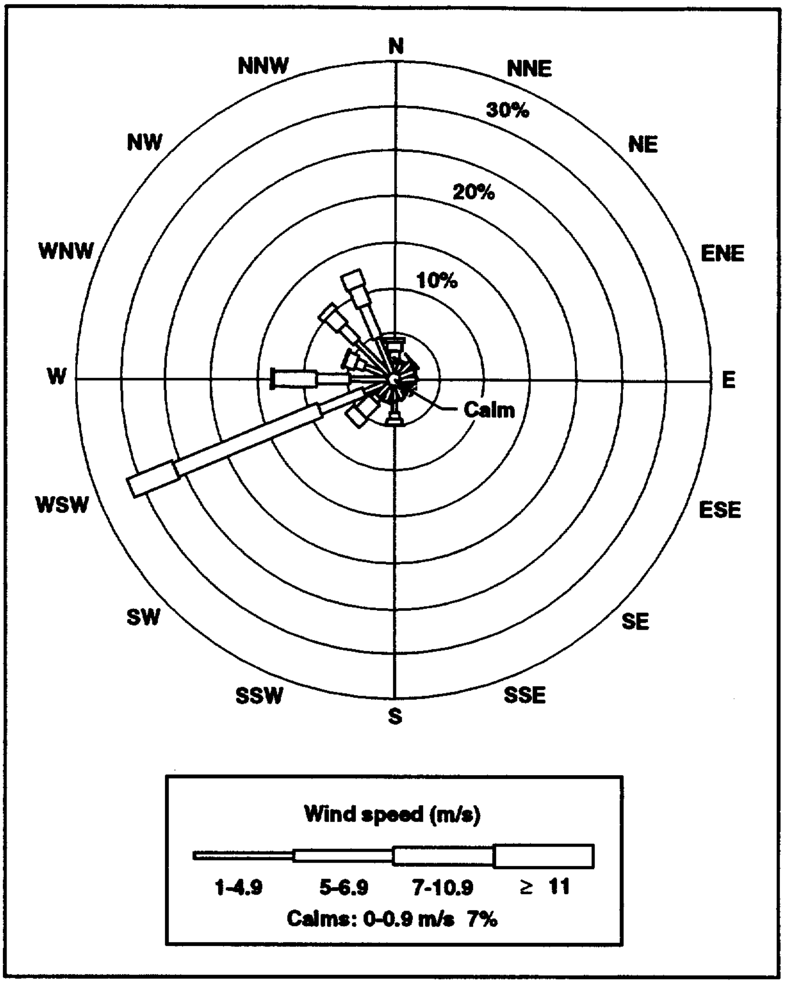

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Figure 1.2-3. Wind rose showing the average annual wind speed and direction at Site 300 for 1990 (adapted from Sims *et al.*, 1990). Note: m/s = meters per second.

Prior to 1984, explosives particulates contained in water and solvents were burned with the aid of excelsiors (fibrous combustibles) in Pit 2. Once or twice a month liquid waste was poured onto a fibrous mat placed on the ground in one of two separate burn areas in the pit; the mat was then allowed to dry. When dry, the explosives wastes that remained on the mat were burned along with the mat. Later on, filters were installed in process streams. All burning in Pit 2 was discontinued in 1984.

Explosives-contaminated solid wastes, including paper, wood, cardboard, plastic labware, and clothing, are burned in Pit 1. The pit contains a wire mesh burn cage to prevent the escape of burning debris. Typically, explosives wastes are currently burned in Pit 1 once every three to four weeks. In 1991, 124 yd^3 (95 m^3) of contaminated solid explosives wastes were treated. In 1992, record keeping was converted from a volume to weight basis and 1,621 lb (735 kg) of solid wastes were treated.

Explosives process particulates are now filtered from the processing water during the manufacturing process. Clarifiers and filters in explosives-processing facilities remove explosives particulates from the rinsewater streams before the wastewater is routed to the evaporation Class II surface impoundments located near Building 817. The fines, consisting of wet shavings and particulates of explosives compounds, are collected in clarifier bags. Wet explosives-contaminated clarifier bags are treated in the "Iron Horse" burn unit located next to Pits 1 and 2 (Fig. 1.2-4). The burn unit contains a burner, which provides a constant heat source to dry the wet explosives waste to the point that it can burn freely. During 1991, 1082 lb (492 kg) of wet explosives waste were treated and 1,896 lb (860 kg) in 1992.

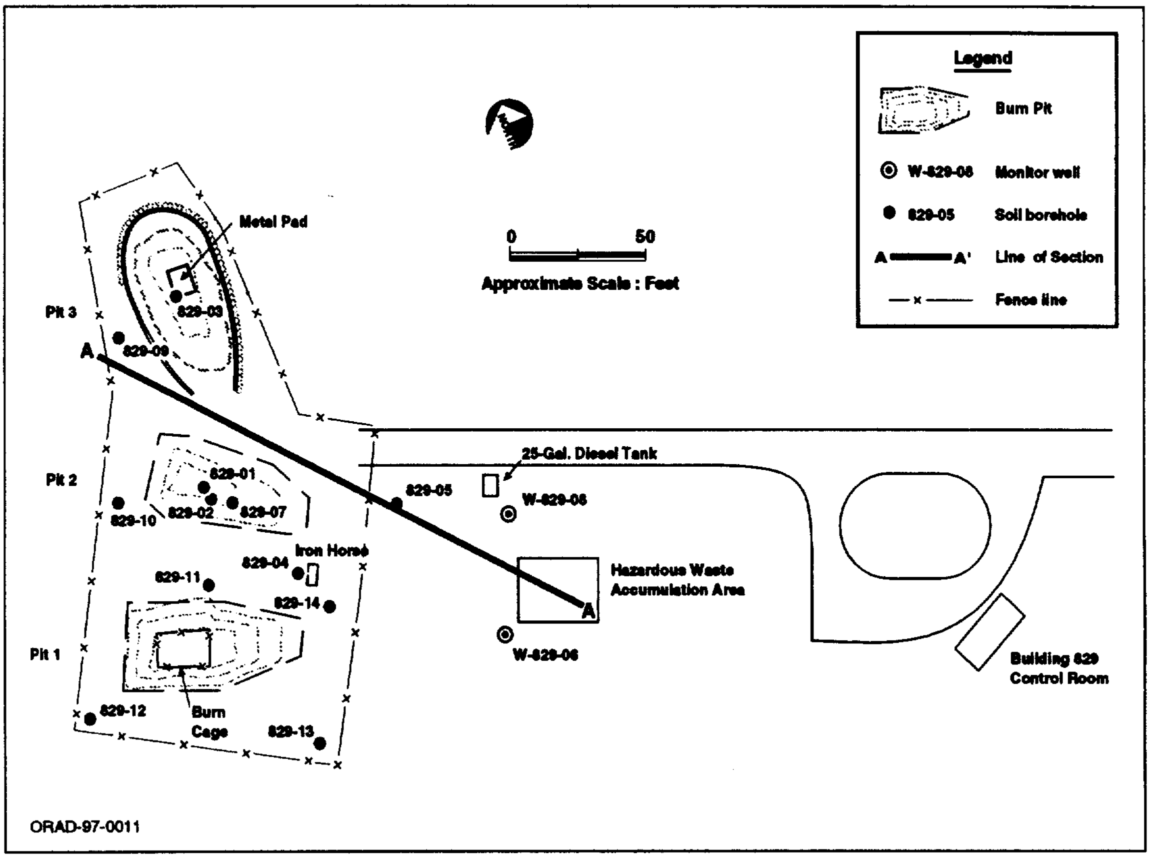

Figure 1.2-4. Building 829 Complex HE Open Burn Treatment Facility, LLNL Site 300.

Fragments of dry, bulk explosives waste are burned in Pit 3 an average of once a month. Larger explosives waste fragments are sometimes generated during explosives machining, and explosives fragments are collected from experiments in which the test fails to detonate the explosives component and from those that result in incomplete detonation. Bulk explosives waste that has no further experimental or testing value is also burned in Pit 3. The explosives waste is placed on an 8-ft^2 slab of armor-plate steel and ignited remotely from the control bunker. Burning is aided by the addition of an excelsior (wood shavings, straw) and a small amount of kerosene (Webster-Scholten and Crow, 1989; Epley, 1990). During 1995, 111 lb (50.3 kg) of dry bulk explosives waste were treated and 306 lb (139 kg) in 1996. We estimate that over 90% of the amount of wastes treated is generated by ongoing activities.

1.2.3 Maximum Extent of Operations [22 CCR 66265.112(b)(3) and 40 CFR 265.112(b)(3)]

Although the Site 300 Open Burn Treatment Facility contains four separate treatment units, only one burn unit is loaded or operated at any time. The maximum inventory of the facility is the capacity of the largest unit. The capacities of the units are given in Table 1.2-1.

Table 1.2-1. Explosives treatment capacity at Building 829 HE Open Burn Treatment Facility, Site 300.

Equipment	Waste Stream	Maximum Capacity
Open Burn Unit (Iron Horse)	Fine explosives particulate collected in process clarifiers	55 lb
Burn Pit 1 (Burn Cage)	Explosives-contaminated solid debris (paper, cardboard, wood, etc.)	200 lb
Burn Pit 2 (Inactive)	Explosives-contaminated waste water	None*
Burn Pit 3	Bulk HE	200 lb

*After discontinuation of wastewater treatment by filter pad absorption in 1984.

1.3 Waste Descriptions

The wastes treated at the HE Open Burn Treatment Facility are hazardous primarily because of their reactivity. The four principal explosives compounds that have been treated at the HE Open Burn Treatment Facility are: HMX (cyclotetramethylene tetranitramine), RDX (cyclotrimethylene trinitramine), TATB (triamino-trinitrobenzene), and TNT (2,4,6-trinitrotoluene).

1.3.1 Waste Characterization

The wastes treated at Building 829 were determined to be reactive by generator knowledge. The treatment of explosives waste by open burning generates an ash waste that is collected and is properly characterized for waste disposal options.

Waste ash samples obtained at the HE Open Burn Treatment Facility are analyzed annually for metals and volatile organic compounds (VOCs). Analytical data for waste ash in the HE Open Burn Treatment Facility are presented in Appendix A. The data indicate that lead and copper are the only metals present in the waste ash above the soluble threshold limit concentration (STLC) [22 CCR 66261.24 (a)(2)]. None of the VOCs were present in concentrations greater than their respective designated threshold levels (see section 1.3.2.2).

1.3.2 Waste Hazards

Two potential hazards associated with explosives wastes at Site 300—reactivity and toxicity—are discussed below.

1.3.2.1 Reactivity

The presence of explosives contamination detected in the subsurface soils at the HE Open Burn Treatment Facility does not pose a risk of explosion during or after closure. Pieces smaller than the critical diameters will not propagate a detonation even when exposed to extreme shock waves; thus, the few parts per million or less quantities of explosives dispersed in the subsurface soils cannot sustain an explosion. Furthermore, the placement of soil and geosynthetic low-permeability and drainage layers will totally isolate all subsurface residual explosives contamination.

1.3.2.2 Toxicity

1.3.2.2.1 Summary of Methodology and Criteria. Water quality criteria for protecting all existing and probable future beneficial uses of the water were selected based on *A Compilation of Water Quality Goals* by Marshack (1995).

Constituent	Water Quality Goal	Soluble Designated Threshold Level	Basis
HMX	**400.0 μg/L**	**2,000.0 μg/kg**	**EPA SNARL**
RDX	**2.0 μg/L**	**10.0 μg/L**	**EPA SNARL**
	0.3 μg/L	**1.5 μg/kg**	**EPA Advisory (10^{-6} cancer risk estimate)**
Trichloroethylene (TCE)	**5.0 μg/L**	**25.0 μg/kg**	**Calif. & Federal MCL**
Trinitrotoluene (TNT)	**1.0 μg/L**	**5.0 μg/kg**	**EPA Advisory (10^{-6} cancer risk estimate)**

Designated threshold levels (DTLs) are constituent concentrations in solids that provide a site-specific indication of the waste's potential to impair ground water quality. Concentrations greater than the DTL are assumed to pose a water quality threat at the site. The DTL is determined by specifying the water bodies potentially affected, the water quality goals that protect the potential beneficial uses of water, and the magnitude of expected environmental attenuation that would reduce the designated level to the water quality goal by the time the contaminant reaches the water body.

1.3.2.2.2 Site 300 DTLs. Even though we propose to cap the B-829 site, we have provided DTL values for the principal contaminants to illustrate the inherently low level of potential threat represented by the small quantities of these chemicals in the soil of the site. The DTL for RDX at the HE Open Burn Treatment Facility was determined by Webster-Scholten and Crow (1989) following Marshack's methodology (1987 a,b). The water body potentially impacted is the regional ground water located more than 300 ft beneath the HE Open Burn site. To calculate the RDX DTL, Webster-Scholten and Crow used an attenuation factor of 100, which is also applied by Marshack to contaminant concentrations occurring in an average site in Central Valley alluvium with 5 to 50 ft of unsaturated strata containing appreciable clay or silty clay. Thus, the above DTLs are conservative for the HE Open Burn site because the thickness of unsaturated alluvium and bedrock at the site is more than six times greater, more than 300 ft, and the sedimentary units contain larger fractions of clay than the typical Central Valley alluvium. The Marshack methodology would allow an attenuation factor greater than 100 to be applied to this site based on the actual depth to the regional aquifer and on additional field data available from tests conducted at the Louisiana Ordnance Plant.

The above DTLs are also reduced by a factor of 20 to correct for the twenty-fold dilution that occurs following the toxicity characteristic leaching procedure (TCLP) protocol. TCLP was not performed on the soil samples. Instead, we perform a worst-case evaluation by assuming that all the HMX, RDX, and TNT present in the sample are extracted by the TCLP protocol. Under those worst-case assumptions, the HMX and TNT DTLs were not exceeded by any of the soil samples collected to date. Assuming complete extraction, the soil sample containing the greatest amount of RDX could exceed the DTL by a factor of 30. However, RDX has a very low solubility in water so it is probable that the RDX concentration in the TCLP aqueous extract will be less than the DTL. Unfortunately, it will not be possible to demonstrate that the DTL is not exceeded because both the DTL and the probable RDX TCLP concentrations will also be below the RDX detection limit (14 to 30 µg/L).

Regardless of the DTL values, the most important mitigation to any potential adverse impact of soil contaminants is the presence of an impermeable clay cap, which will ensure that no further migration of the contaminants can occur. Moreover, the concentrations of contaminants found in the soil of the site are so low that even direct contact with the soil would not constitute an acute exposure. Finally, the noninvasive construction techniques used in this closure (proof-rolling followed by clean-soil foundation layer fill) will result in minimal contact with the existing soil.

1.3.3 Soil and Ground Water Monitoring

1.3.3.1 Summary of 1989 Remedial Investigation

The remedial investigation (RI) and results are presented in an LLNL report by Webster-Scholten and Crow (1989), which is briefly summarized in this section. The soil and ground water data from this investigation are presented in Appendix C.

Eight 9-in.-diam boreholes, 829-01 through 829-08, were drilled between November 1986 and January 1987 within the facility. No boreholes were drilled upgradient from the facility because of local topography. Borehole W-829-06 was subsequently converted to a monitoring well and W-829-08 was drilled nearby (Fig. 1.2-4). These wells are probably hydrologically downgradient or cross-gradient in the shallow water-bearing zone that they monitor.

Three boreholes, 829-01, 829-02, and 829-07, were drilled in the bottom of Pit 2; 829-03 was drilled in the middle of Pit 3; 829-04 was drilled adjacent to the Iron Horse; 829-05 was drilled just outside the entrance to the Open Burn Treatment Facility; and W-829-06 and W-829-08 were drilled adjacent to the former drying shed (Fig. 1.2-4). The wire mesh cage prevented drilling in the bottom of Pit 1. Soil samples were collected for analysis of VOCs, explosives compounds, and metals. Geologic logs were prepared for each borehole (Appendix B). Soil samples were analyzed for explosives compounds by high-performance liquid chromatography (HPLC), for VOCs by EPA Method 8010 or 8240, and for metals by the California Waste Extraction Test (WET) as prescribed by the California Code of Regulations, Title 22.

Results of soil analyses (Table C-1 in Appendix C) indicate that explosives compounds, RDX and HMX, are present in soils at low concentrations. The higher concentrations generally occur at the surface and decrease rapidly with depth. The highest concentrations were detected in Pit 2 with 0.91 µg/g RDX from 4 to 5 ft in borehole 829-01 and 3.95 µg/g HMX from a shallow sample in borehole 829-02. Concentrations in samples from shallow boreholes adjacent to Pits 2 and 3 were below 1 µg/g.

Analyses for VOCs in soil and rock (Table C-2) indicate that TCE, chloroform, trans-1,2-dichloroethane, and 1,2-dichloroethane were present in samples from beneath Pits 2 and 3. TCE, the most abundant VOC detected, was reported at concentrations far below the DTL of 5 µg/g. The DTL is calculated using the Department of Health Services Maximum Contaminant Level (MCL) methodology and an attenuation factor of 100 as described in section 1.3.2.2.

Samples from several boreholes were tested for metals. Detectable concentrations of antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, and vanadium occurred sporadically to 44.4 ft. Mercury, molybdenum, silver and thallium were not reported above the detection limit at any depth. Two metals, barium and zinc, were present in every sample from borehole 829-01. The highest concentration of metals was detected in the shallowest (2.0 ft) sample (Appendix C). Sample data are presented in Table C-3.

As part of its remedial investigation study at Site 300, LLNL has made a limited determination of background concentrations of potentially toxic metals and metalloids in Site 300 surface soil. Background concentrations of these substances in typical worldwide shales, sandstones, and uncultivated soil have also been compiled. These data are presented in Table C-7. A comparison of the background data with the concentrations of metals and metalloids detected in boreholes (Table C-3) shows that these concentrations are within the ranges expected for natural background for an area underlain by sandstone and shale bedrock.

The two boreholes near the hazardous waste storage area were completed as wells. Ground water samples were collected from wells W-829-06 and W-829-08. Water samples are collected quarterly from well W-829-08 and the analytical results are presented in Appendices C and H. Sampling of well W-829-06 began during the fourth quarter of 1992. No explosive compounds have been detected in any water samples collected from W-829-06 or W-829-08. VOCs detected in water samples from these shallow wells include TCE. Of the quarterly samples analyzed through June 1996 from W-829-06 and W-829-08, 40 contained TCE, and of those, 25 were above the MCL of 5 µg/L. The most recent quarterly monitoring results for June 20, 1996, indicated that water from well W-829-08 contained 17 µg/L of TCE, while a ground water sample collected on the same date from well W-829-06 contained 380 µg/L of TCE.

The explosives compounds and VOCs detected in soil and ground water at the Open Burn Treatment Facility are believed to have been released during past operations of the facility. Remedial investigation studies document local VOC contamination of a perched water-bearing zone but, as documented in section 1.4.2 below, this water-bearing zone is disqualified as a potential water-supply source under San Joaquin County regulations. The RI concluded that the concentrations of explosives compounds, VOCs, and metals in soil samples collected from the HE Open Burn Treatment Facility will not be a threat to public health or the beneficial uses of ground water. Based on findings of the RI, this closure plan concentrates on assuring future isolation of soil contaminants present to prevent human contact and to minimize the potential for leaching and migration to ground water.

1.3.3.2 Summary of 1990 Soil Analyses

Shallow subsurface conditions of the HE Open Burn Treatment Facility pad were further explored by drilling and sampling six test boreholes, 829-09 through 829-14, in the locations shown in Figure 1.2-4. Each of the boreholes was drilled with a truck-mounted CME 750 drilling rig equipped with 8-in., hollow-stem, continuous flight augers to depths ranging from 8.5 to 16 ft below ground surface. Samples were collected for geotechnical testing and chemical analyses.

For geotechnical testing, samples of the site soil were recovered with both 1.375- and 2.5-in.-i.d., split-spoon samplers. The samplers were mechanically driven into the soil with a 140-lb hammer with a free fall drop of 30 in. The number of blows required to drive the sampler 6 in. was recorded in the field and then converted to standard penetration blow/ft by American Standard Testing Method (ASTM) D-1586. The geotechnical borehole logs are presented in Appendix B.

Samples from the test boreholes were transported to Rogers/Pacific soils laboratory in Pleasant Hill, California, for geotechnical testing and analysis. The laboratory testing program was designed to determine the engineering properties of the site materials. Soil properties tested included natural water content, *in situ* dry density, Atterberg Limits, and shear strength parameters. Results of the geotechnical testing and analysis are discussed further in section 1.6.3, and a summary of the laboratory test data is presented in Appendix F.

Soil samples for chemical analysis of near-surface soils were collected to supplement the data from the 1989 remedial investigation. Samples were collected by lining the split-spoon samplers with brass tubes. The tubes were immediately capped with Teflon tape and plastic end caps, hermetically sealed with duct tape, and labeled. The samples were then refrigerated for transport under chain-of-custody to the analytical laboratories. Soil samples were analyzed for explosives compounds (HMX, RDX, and TNT) by HPLC, for

VOCs by EPA Method 8010, and for metals by the WET method, which is preferred by the DTSC. In addition, samples from 2-ft and 8.3-ft depths in borehole 829-14, adjacent to the 25-gal underground diesel tank, were analyzed for diesel by modified EPA Method 8015. Geologic logs were prepared for each borehole to supplement the logs prepared by the geotechnical contractor. The logs describe, as appropriate, the lithologic character of the cuttings or core (soil/rock type, grain size, color, hardness, relative moisture content, minor constituents, bedding thickness, laminae, etc.), presence or absence of fractures, and other pertinent geologic data. These logs are included with the geotechnical logs in Appendix B.

Analytical results for soil samples from the 1990 sampling are summarized in Appendix C. HMX was detected in samples from four of the six boreholes, at a maximum of 0.451 µg/g at 4.8 ft from the borehole 829-11 adjacent to Pit 1. RDX was detected in only one sample, from 4.2 ft in borehole 829-09, located east of Pit 3. All HE concentrations are below the DTL established for RDX. TNT was not detected in any of the samples. TCE was detected in samples from boreholes 829-09 and 829-11, at a maximum of 0.028 µg/g at 2.8 ft in borehole 829-09. This is less than the DTL of TCE. Where metals were detected in borehole samples, concentrations were all significantly below the soluble threshold limit concentrations. We anticipate that similar results would occur with the extraction TCLP, although not conducted, because the metal concentrations from the WET test were so low.

1.3.3.3 Subsequent Investigations

During the later portion of 1990, two deep wells for regional ground water monitoring, W-827-04 and W-827-05, were drilled about 1000 ft southeast of the HE Open Burn Treatment Facility area (Fig. 1.3-1). Logs of W-827-04 and W-827-05 are included in Appendix B.

W-827-04 was completed at about the 300-ft depth where field operations had suggested saturation in fractured silty sandstone beds that are possibly correlative with the upper portion of the regional aquifer identified and characterized farther to the southeast in the HE Process Area (Crow and Lamarre, 1990). Subsequent observations showed no persistent saturation in these strata. No evidence for shallower water-yielding zones was observed during drilling of this monitoring installation.

W-827-05 was completed between depths of 379 and 408.5 ft in sandstone and conglomerate beds believed correlative with the deep water-production zone present in the western GSA, Site 300. A stabilized water level at a depth of 373 ft beneath the point-of-measurement was recorded in this well on December 21, 1990. Ten water samples have been collected from W-827-05. Except for 0.7 ppb of 1,1,1-TCA reported in a sample collected on September 11, 1991, no VOCs or explosives compounds were detected in these samples. This reported presence of 1,1,1-TCA has not been confirmed by subsequent analyses. The analytical results are summarized in Appendix C.

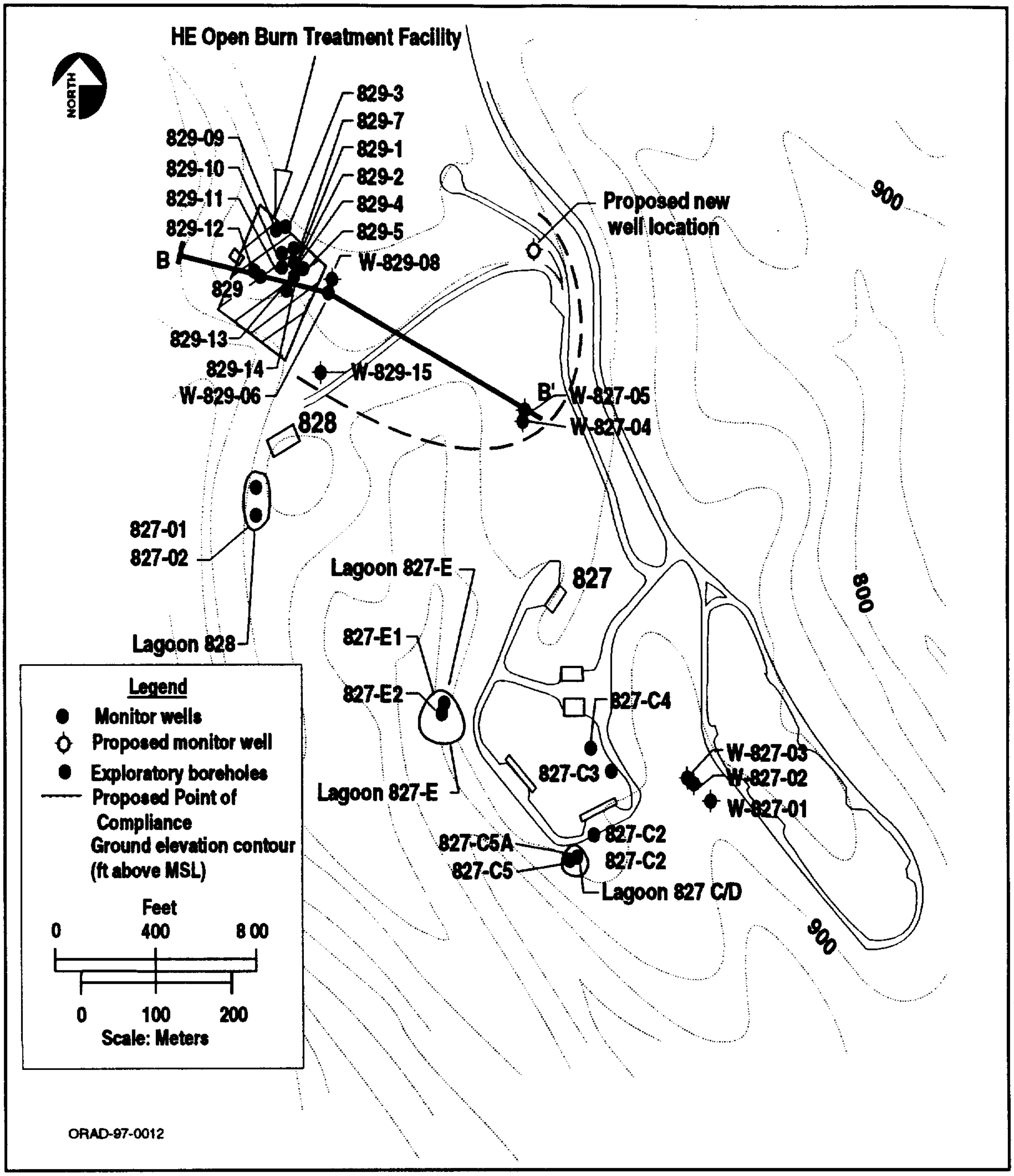

Figure 1.3-1. Map showing locations of HE Open Burn Treatment Facility, boreholes, and monitor wells.

During the summer of 1994, well W-829-15 was completed within the regional aquifer between the depths of 382 to 392 ft. The potentiometric surface is approximately 340 ft below ground surface at the Building 829 area. Ground water samples from this well have only been analyzed for metals, minerals, and indicator parameters. These data are included in Appendix H.

In October 1994, the existing 30-gal diesel fuel tank system (UST-829-D1U1), comprised of a 30-gal, low, carbon steel drum and approximately 15 ft of piping, was removed and replaced with a new 25-gal aboveground double-walled tank system (AST-829-D1A1). Soil samples from the excavated ground surface 11 ft below grade contained up to 1600 mg/kg total petroleum hydrocarbons-diesel (TPH-D) and 0.076 mg/kg xylene. In December 1994, the tank area was excavated to 17 ft below ground surface. Results indicated a TPH-D of 990 mg/kg. The presence of this constituent infers that another tank may have pre-dated the 30-gal tank, which was installed in 1983. Additional sampling and analysis was conducted at the 17-ft excavation and ranged from 58.0 mg/kg TPH-D to 930 mg/kg TPH-D. Based upon the visual inspection of the tank and its physical integrity, analytical results of the soil samples collected from the excavation, successful completion of the sampling plan outlined in the May 1994 Closure Plan for the UST-829-D1U1, and a local depth to ground water of over 100 ft bgs, the San Joaquin County Public Health Services Environmental Health Division issued a "no further action" letter to LLNL on February 24, 1995. The excavation was filled and restored to grade.

1.4 Geology and Hydrogeology

1.4.1 Site 300 Geology

Site 300 is located within a series of steep canyons and hills mantled by Quaternary colluvium. Beneath the colluvium is bedrock composed of Pliocene continental sediments and Miocene to Cretaceous volcaniclastic rocks and marine strata. Alluvial deposits are locally present and are composed predominantly of terrace and flood plain deposits and ravine fills. Bedrock structure is complex, as several folds and minor faults exist beneath the site. Figure 1.4-1 is a general geologic map of Site 300.

1.4.1.1 Previous Work

Knowledge of the geology of Site 300 is based on the regional geologic mapping by Huey (1948), Raymond (1969), and Dibblee (1980a and b), supplemented by observations made during detailed hydrogeologic studies of portions of Site 300 conducted by LLNL in recent years (Raber and Carpenter, 1983; Carpenter *et al.*, 1983, 1986, and 1988; Buddemeier *et al.*, 1985; Taffet *et al.*, 1989; McIlvride *et al.*, 1990; and Crow and Lamarre, 1990).

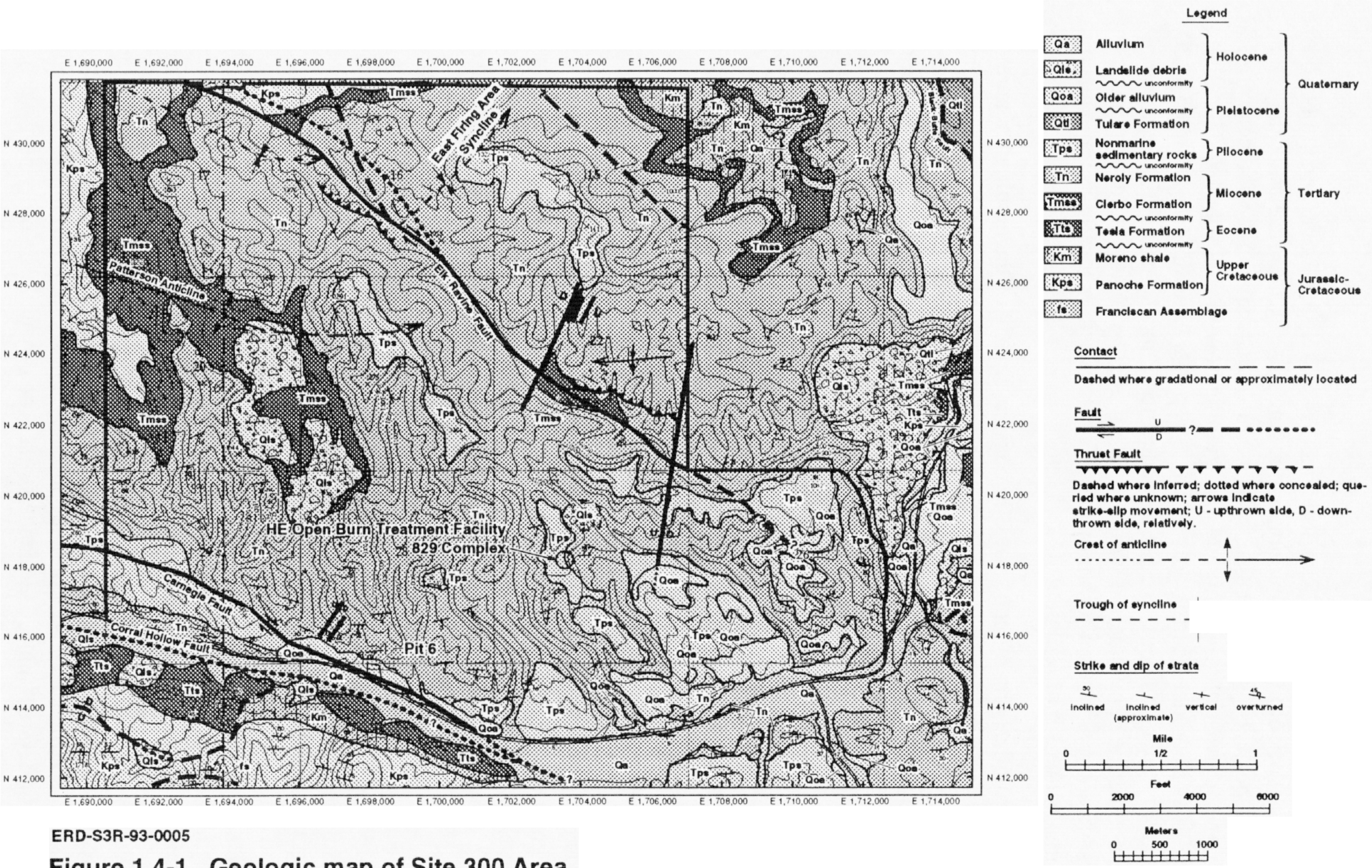

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Figure 1.4-1. Geologic map of Site 300 Area.

1.4.1.2 Stratigraphy

Unconsolidated deposits in the Site 300 area (Fig. 1.4-1) are Pleistocene to Holocene in age and consist of colluvium, alluvium, and ravine fills (Qa), terrace alluvium (Qoa), and landslide deposits (Qls). Terrace deposits are most extensive in the southern portion of Site 300; they consist of sandy silt and clay grading downward to sand and locally to coarse cobble- and boulder-bearing gravel. These deposits typically range from 3 to 30 ft in thickness, but may be as thick as 55 ft. An unnamed Pliocene unit (Tps) is present and consists of nonmarine conglomerate with pebbles of angular to subrounded graywacke and chert, sandstone, and green-to-brown clay. This unit occurs locally as remnants of a once continuous blanket of sediment.

The bedrock underlying most of Site 300 consists chiefly of the continental and estuarine, largely volcaniclastic, sedimentary rock of the late Miocene Neroly Formation (Tn). The Neroly Formation is up to 470 ft thick and is composed of distinctive blue weathering sandstones and siltstones, coarse conglomerates of well-rounded andesitic and basaltic pebbles and cobbles, and interbedded tuffaceous shales. Within Site 300, the Neroly Formation has been subdivided into three informal stratigraphic members. These are $Tnbs_2$ (upper blue sandstone), $Tnsc_1$ (middle claystone-siltstone unit), and $Tnbs_1$ (lower blue sandstone). Other informal stratigraphic members have been defined locally as a result of detailed study area investigations. As shown on geologic cross-section B-B' (Fig. 1.4-6), the three principal informal stratigraphic members of the Neroly Formation are present in the subsurface beneath the HE Open Burn Treatment Facility.

The Neroly Formation is unconformably underlain by the interbedded, coarse-grained, friable sandstone; carbonaceous blue-to-brown shale; and tuff of the shallow marine and continental, early Miocene Cierbo Formation (Tmss). Sandstone of the Cierbo Formation commonly appears yellow to brown gray in borehole cuttings. This sandstone is micaceous, quartz-rich, and pyritic, and is characterized by a high degree of sorting and the presence of well-rounded chert pebbles. The formation has an average thickness of 200 ft in the Site 300 area.

The Tesla Formation (Tts) is exposed on State Vehicle Recreation Area property east of Pit 6 and in the hills southwest of Site 300. It unconformably underlies the Cierbo Formation and may locally underlie other parts of Site 300 at depth. The Tesla Formation is a heterogeneous sequence of brackish water and marine sedimentary rocks of late Paleocene to early Eocene age and includes some thin coal seams. The unit is 1,200 to 1,500 ft thick where exposed south of Site 300. In the northern portion of Site 300, Cierbo Formation rocks are directly underlain by Great Valley sequence rocks; thus, the Tesla Formation pinches out in this area.

Great Valley sequence rocks are exposed only in the northern and western portions of Site 300 where they consist of predominantly fine-grained turbidite sandstone with some micaceous shale interbeds. These strata are probably a portion of the Upper Cretaceous Panoche Formation. Great Valley sequence strata probably underlie other portions of Site 300 at depth. Franciscan rocks are not exposed within Site 300, although regional geophysical studies (Taylor and Scheimer, 1981) suggest the presence of these rocks at great depths beneath the site.

1.4.1.3 Structural Relationships

As shown in Figure 1.4-1, bedrock structure at Site 300 is dominated by the Patterson Anticline, which trends west-northwest/east-southeast as it crosses the central part of Site 300. South of the anticlinal ridge, the bedrock sequence dips southward toward Corral Hollow. North of the ridge crest, beds dip toward the northeast an average of 10° into the trough of a subsidiary syncline that crosses the northeastern portion of Site 300. The synclinal axis plunges northeast. Immediately northeast of the trough, beds dip southwest for a short distance before resuming a regional northeasterly dip toward the San Joaquin Valley.

Two principal faults are mapped within Site 300:

- The Elk Ravine Fault, in the north-central part of the site; and
- The Carnegie Fault, which crosses the southwestern portion of Site 300.

Dibblee (1980a and b) shows the Carnegie Fault merging northwest of Site 300 with the Patterson Pass and Corral Hollow Faults and southeast of Site 300 with the Corral Hollow Fault. Neither the Elk Ravine Fault nor the main branch of the Carnegie Fault shows evidence of Holocene displacement (Raber and Carpenter, 1983; Hoffman, 1988). Several other faults of local extent have recently been identified by trenching and field mapping in the HE Process Area and East Firing Area (EFA) of Site 300 during LLNL studies (Fig. 1.4-1). These include northeast-trending normal faults and near east-west-trending reverse faults. The latter are exposed mainly on the southern limb of the Patterson Anticline. These faults locally offset the Pliocene nonmarine unit (Tps), but they are not known to offset younger strata. Further geologic mapping has revealed additional shears, thrusts, and normal and reverse faults of local extent in southeastern Elk Ravine, in the central portion of Site 300, and north and west of Pit 6 (Dugan and Mateik, 1990). During recent geologic mapping in the southwestern part of Site 300, evidence of Holocene movement was discovered along a fault strand within the Corral Hollow–Carnegie Fault Zone (Carpenter *et al.*, 1991). The potentially active fault strand occurs near closed landfill Pit 6 approximately 1 mile southwest of the HE Open Burn Treatment Facility area (Fig. 1.4-1).

During geologic mapping in the vicinity of the HE Open Burn Treatment Facility, a small fault of local extent was noted in a ravine on the southwest side of the facility. This fault occurs in the ravine that separates the burn area from the site of the explosives waste accumulation area. The fault offsets beds of the Neroly Formation vertically by about 10 ft, southeast side up. The contact between the Neroly Formation and the overlying Pliocene nonmarine sequence of Dibblee (1980a and b) appears similarly displaced; however, the fault cannot be readily traced in the Pliocene nonmarine sediments, suggesting that it has not been active during Quaternary time. Similar small faults have been mapped at other locations within Site 300 (Dugan and Mateik, 1991). Because of their limited extent (typically less than 1 mile in length), these faults are not potential sources of strong ground motions or major displacements. However, some, particularly those near the Corral Hollow–Carnegie Fault Zone, may move sympathetically during a future earthquake, resulting in minor amounts of surface displacement along the fault trace. The small fault mapped near the HE Open Burn Treatment Facility shows no geologic evidence that suggests linkage to any potentially active faults.

Rocks within Site 300 are pervasively fractured. Fractures include joint sets, fractures subparallel to bedding planes, and shear zones. Frequently, thin-bedded claystones are intensely and randomly fractured.

Joint sets are observed most often in the well-indurated rocks present within Site 300. These rocks include the Great Valley sequence, Tesla Formation, and Neroly Formation. Joint sets are locally observed in more indurated portions of the Pliocene nonmarine unit, but well-defined joints are uncommon in these sediments and in the poorly indurated Cierbo Formation strata.

Figure 1.4-2 shows the orientations of principal joint sets measured at various locations within Site 300. Although no joint set measurements were made at the Open Burn facility itself, data in Figure 1.4-2 include measurements made adjacent to Building 828 about 600 ft south of the facility.

At most locations, three joint set orientations are evident. These joint sets include one striking nearly north, one trending northeast, and one that varies in strike from northwest to nearly east-west. All joint sets dip steeply, generally between 60 and 90 degrees. At some locations, a given joint direction is represented by two antithetic joint sets that make an acute angle of 15 to 30 degrees with one another. There, four or more joint sets may be visible. At other locations, only two joint sets are present. In the southeastern part of Site 300, the set striking nearly north is only observed locally (Fig. 1.4-2). The set trending northeast is occasionally absent in other parts of the site. The northwest to near east-west trending set is generally present in exposures throughout Site 300.

Figure 1.4-2 includes an upper hemisphere stereographic plot of poles to the joint planes measured within Site 300. The plot shows a typical configuration for a geologic setting in which steeply dipping joints predominate.

Concentrations of poles reflect the dominance of joints with attitudes previously described. In addition, the stereographic plot reveals a paucity of joints with strikes in the range of N 40°E to N 60°E, and a secondary low in the abundance of joints with strikes in the N 40°W to N 60°W range. Thus, joints with these trends that could serve as fracture-flow pathways are rare at Site 300.

Joint spacings may locally exceed 3 ft in massive sandstone and conglomerate beds. However, in the more prevalent thin- to medium-bedded sandstones and well-indurated claystones, joint spacings are characteristically 0.2 to 1.5 ft. In outcrops, joint and fracture planes are commonly open and frequently coated with carbonates and iron oxides.

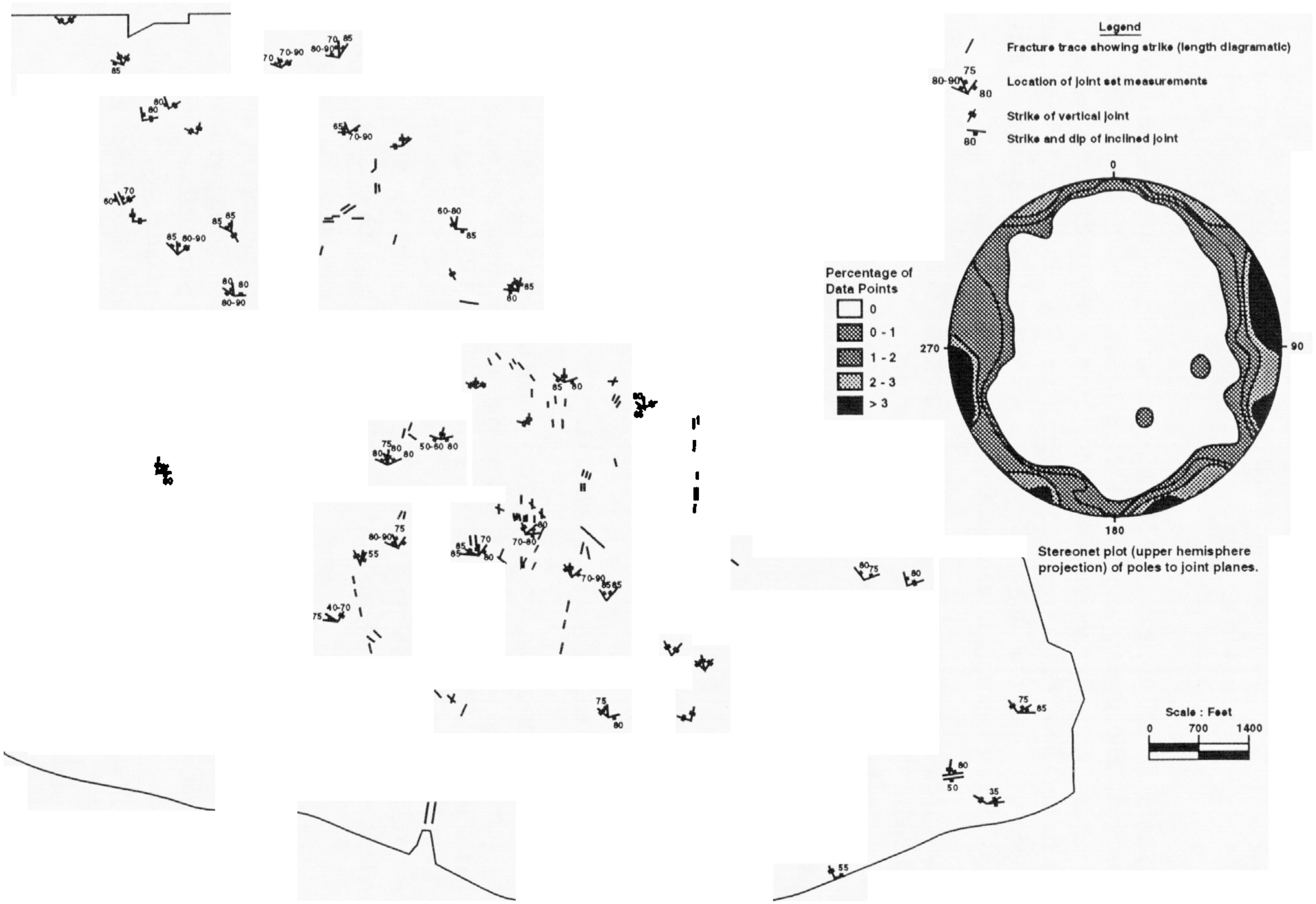

Figure 1.4-2. Orientations of principal joint sets and fracture traces at LLNL Site 300.

Cores from monitor wells and exploratory boreholes contain fractures. Fracture intensity has been characterized using the Rock Quality Designation (RQD) system of Deere *et al.* (1969). Measured RQD values are shown on individual well and borehole logs listed in Appendix B.

In drill cores, iron and manganese oxide and other weathering products are visible on some fracture and bedding plane surfaces to average depths of about 100 ft. The presence of these minerals suggests circulation of oxygen-bearing ground water to these depths through the fracture network. At greater depths, fractures may initially appear closed and gradually open as the core dries and *in situ* stresses are relieved. Fractures at depth may also be filled with carbonates, sulfides, opaline silica, and clay minerals.

Joints and fractures present at Site 300 are interconnected in the near field, but large interconnected fracture networks do not appear to be present. Observations suggest that individual fractures do not persist for long distances. Independent evidence in support of these observations is provided by the 2-orders-of-magnitude difference in TCE concentrations in monitoring wells W-829-06 and W-829-08. This large difference in TCE concentration is present even though the two wells are only about 45 ft apart (Fig. 1.2-4). If the joints and fractures present in the claystone water-bearing zone beneath the study site had created an interconnected, permeable network, aqueous diffusion and transport would have resulted in a more homogeneous contaminant plume than that detected beneath the Open Burn facility.

1.4.2 Site 300 Conceptual Hydrogeologic Model

This section summarizes the conceptual hydrogeologic model of Site 300, based on the findings presented in several previous and ongoing investigations conducted at the site. These studies include the Pit 6 RI/FS, the Pit 7 RI/FS, Pit 8 RI/FS, Pit 9 RI/FS, Building 850/East Firing Area RI/FS, Building 834 RI/FS, General Service Area RI/FS, HE Process Area RI, and the Building 833 RI. The areas are identified in Figure 1.4-3, and the associated documents are included in the Site 300 Bibliography (see Reference section).

To form this model, we assessed the stratigraphy, structure, geochemistry, hydrogeology, soil moisture, geomorphology, and physical characteristics of aquifers and aquitards within Site 300 through field mapping, drilling and monitoring well installation, and borehole geophysics. We also attempted to define aquifer permeabilities, preferred pathways of ground water flow, hydraulic barriers, and flow velocities, by conducting and analyzing numerous hydraulic tests, by evaluating flow paths as revealed by the presence of substances of environmental concern, and by analyzing the distribution of potentiometric heads. The resulting conceptual model also considers natural and anthropogenic water chemistry.

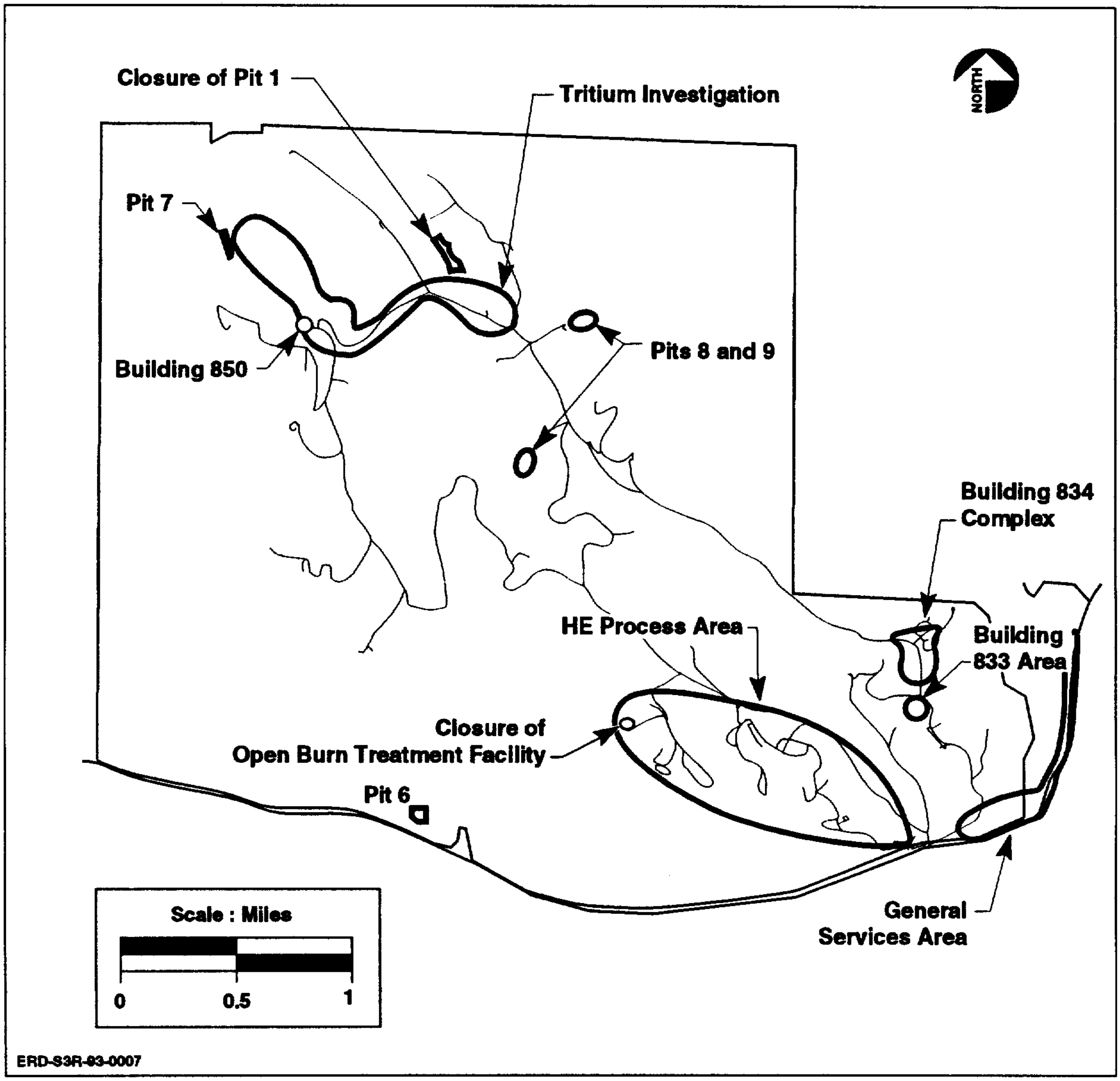

Figure 1.4-3. Areas of investigation at Site 300.

Eight primary hydrologic units have been identified within Site 300. In order of increasing age and depth, the hydrologic units are:

- Quaternary terrace and alluvial deposits (Qa, Qoa),
- Pliocene nonmarine water-bearing zones (Tps),
- Neroly upper siltstone/claystone confining layer ($Tnsc_2$),
- Neroly upper sandstone aquifer ($Tnbs_2$),
- Neroly middle siltstone/claystone confining layer ($Tnsc_1$),
- Neroly lower sandstone water-supply aquifer ($Tnbs_1$),
- Cierbo claystone/siltstone/clayey sandstone aquitard (uppermost Tmss), and
- Cierbo sandstone aquifer (Tmss).

The Cierbo Formation hydrologic units have been identified only in northerly portions of Site 300. Although we believe the Cierbo Formation (Tmss) occurs at depths beneath the HE Process Area study area, which includes the HE Open Burn Treatment Facility, it has not been encountered during drilling operations.

The principal aquifer within Site 300 is the Neroly lower sandstone water-supply aquifer. A potentiometric surface map for this aquifer as it occurs beneath the southeastern portion of Site 300 is shown on Figure 1.4-4. Characteristics of this aquifer are variable within Site 300. In the southern portion of Site 300, above a deep claystone marker bed, this aquifer consists of several water-yielding zones separated by siltstone-claystone sequences that are believed to act as local aquitards. Hydraulic conditions range from unconfined and locally unsaturated in the north to artesian in the south. Drinking water production wells within Site 300 are completed in deeper portions of the $Tnbs_1$ aquifer that consists primarily of massive sandstone and conglomerate. This water is confined. In the southern portion of Site 300, ground water in the $Tnbs_1$ regional aquifer flows downdip to the southeast, controlled by the southward dip of the southern limb of the Patterson Anticline.

Geologic structure and topographic relief control the lateral extent of saturation and hydraulic gradient of the other water-bearing zones present within Site 300. Ground water is contained primarily within four other hydrologic units: three discontinuous Tps water-bearing zones and the Neroly upper sandstone aquifer ($Tnbs_2$). To a lesser extent, ground water is locally present in the Qal, $Tnsc_2$, and $Tnsc_1$ units. In general, in the southern portion of Site 300, ground water in the primary hydrologic units flows to the south-southeast and is controlled by local structural dip (i.e., the southeast dipping southern limb of the Patterson Anticline). Shallow ground water is present only in the Quaternary alluvium that occurs along the southern fringe of Site 300 (i.e., western GSA) and is believed to flow eastward below the Corral Hollow Creek floodplain.

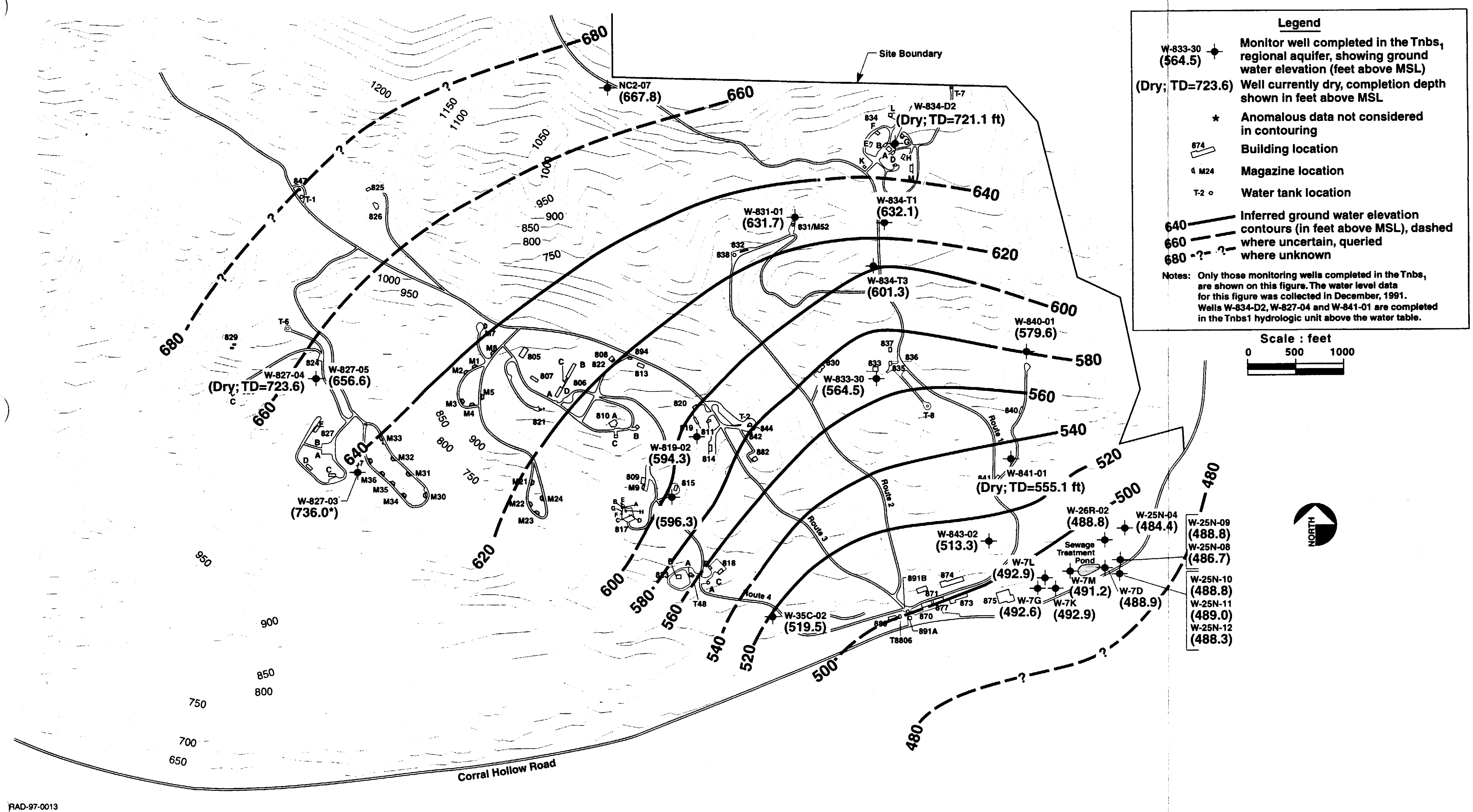

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Figure 1.4-4. Potentiometric map of ground water for the $Tnbs_1$ regional aquifer in southeastern Site 300.

Ground water within the deeper Cierbo Formation aquifer has been identified only in the northwestern portion of Site 300 (Taffet *et al.*, 1990). Because of the presence of swelling clays that irregularly reduce primary porosity, hydraulic characteristics of this deeper aquifer are variable. Flow is probably down the structural dip to the northeast, although little data are available. One or more Cierbo aquifers may underlie the southerly portions of Site 300, but monitoring and water-supply wells have not been drilled to depths required to encounter it.

In the southern portion of Site 300, the first water-bearing zone is typically contained within the Pliocene nonmarine hydrologic unit (Tps). The Pliocene nonmarine unit contains three discontinuous water-bearing zones that range from perched in the north to confined in the south (western GSA). A major perched Tps water-bearing zone, initially identified beneath Building 815, is believed to pinch out or is truncated in the south by an eastwest-trending subsurface fault. This unit is unsaturated south of the fault in the vicinity of Building 818, and it again becomes saturated farther to the south, near the western GSA.

Other perched ground water-bearing zones within the Tps hydrologic unit are located in the vicinity of the Building 834 Complex and at the HE Open Burn Treatment Facility itself. An ephemeral water-bearing zone has been identified in the Building 833 Complex.

Based upon standards established by San Joaquin County for water supplies, none of the perched water-bearing zones present in the southerly portions of Site 300 are potential water-supply sources. Standards not met by these perched zones are as follows:

- Depths to water are less than the 100-ft minimum depth required by San Joaquin County for a potable water source.
- Sustained yields from these water-bearing zones are less than the 5-gpm quantity required by San Joaquin County for a domestic well. Both W-829-06 and W-829-08 are "dry-out" wells. That is, they go dry during purging prior to environmental sampling and recover very slowly. Although sustained yields have not been calculated by hydraulic testing, well behaviors suggest that sustained yields are likely less than one gpm.

The Tps water-bearing zones are hydraulically separated from the underlying Neroly upper blue sandstone aquifer ($Tnbs_2$) by low-permeability siltstone and claystone of the lower Tps unit and the $Tnsc_2$ confining layer. The thickness of these low-permeability zones is variable, owing to the unconformable contact between the Tps and the $Tnsc_2$ units.

At Site 300, the $Tnbs_2$ unit is only saturated in the eastern and southern portions of the HE Process Area. In those locations, the aquifer becomes saturated north of Building 815 and remains saturated to the south (i.e., downgradient) in the western GSA. As a result of structural dip and hydraulic gradient, hydraulic conditions vary from unconfined in the vicinity of Building 815, to confined in the vicinity of Building 818, and finally to flowing artesian in the western GSA.

The Neroly middle siltstone/claystone confining layer ($Tnsc_1$) functions as a lower confining layer to the $Tnbs_2$ aquifer and an upper confining layer to the Neroly lower sandstone aquifer ($Tnbs_1$). Throughout much of Site 300, the $Tnsc_1$ unit is the dominant regional confining layer. Exceptions to this have been identified in the northern and southeastern portions of Site 300, where the unit has been eroded away and the $Tnbs_1$ aquifer is exposed at the surface. Minor water-bearing zones have been encountered locally within the $Tnsc_1$ hydrologic unit.

Approximately 20 springs are present within Site 300 and represent locations where various hydrologic units intersect the ground surface. Spring discharges are generally low and the springs serve only as water sources for wildlife. Evaporation rates are approximately 60 in./yr, resulting in a semiarid climate. Two ground water extraction wells at Site 300 are located in the western GSA. These wells produce ground water from the Neroly Formation lower blue sandstone aquifer. This water is used for drinking water, sanitary, process, and fire suppression purposes.

1.4.3 HE Open Burn Treatment Facility Site

The HE Open Burn Treatment Facility is situated on the southwestern flank of the Patterson Anticline (Fig. 1.4-1), immediately adjacent to a hilltop composed of remnant Pliocene nonmarine sedimentary rocks (Tps). The sedimentary beds on this limb of the anticline have a moderate southerly dip (±10°). Thicknesses of Tps strata remaining beneath the HE Open Burn Treatment Facility are generally less than 15 ft. The Neroly bedrock beneath includes complexly interbedded clay, sandstone, and fractured and weathered claystone with minor beds of gravelly and conglomeratic sandstone and siltstone (Webster-Scholten and Crow, 1989). Informal lithologic members $Tnbs_2$ and $Tnsc_1$ have been encountered in boreholes and wells drilled in the vicinity of the Open Burn Treatment Facility. Member $Tnbs_1$ is present beneath the facility at greater depths. Subsurface relationships at the facility site are shown on geologic cross-section A-A' (Fig. 1.4-5). Subsurface geology from the facility downgradient to regional aquifer monitoring wells W-827-04 and W-827-05 is shown on geologic cross-section B-B' (Fig. 1.4-6).

The abundant fractures in the bedrock are either healed with secondary white mineralization or coated with manganese and iron oxides. Slickensides are noted on numerous fractures at depths ranging between 60 and 90 ft. A small inactive fault is evident in the ravine to the southwest of the Building 829 Complex, but it does not traverse the immediate vicinity of the HE Open Burn Treatment Facility. The fault displaces Pliocene and older sediments. Geologic logs for exploratory boreholes drilled for the Remedial Investigation of the HE Open Burn Treatment Facility (Webster-Scholten and Crow, 1989) are included in Appendix B.

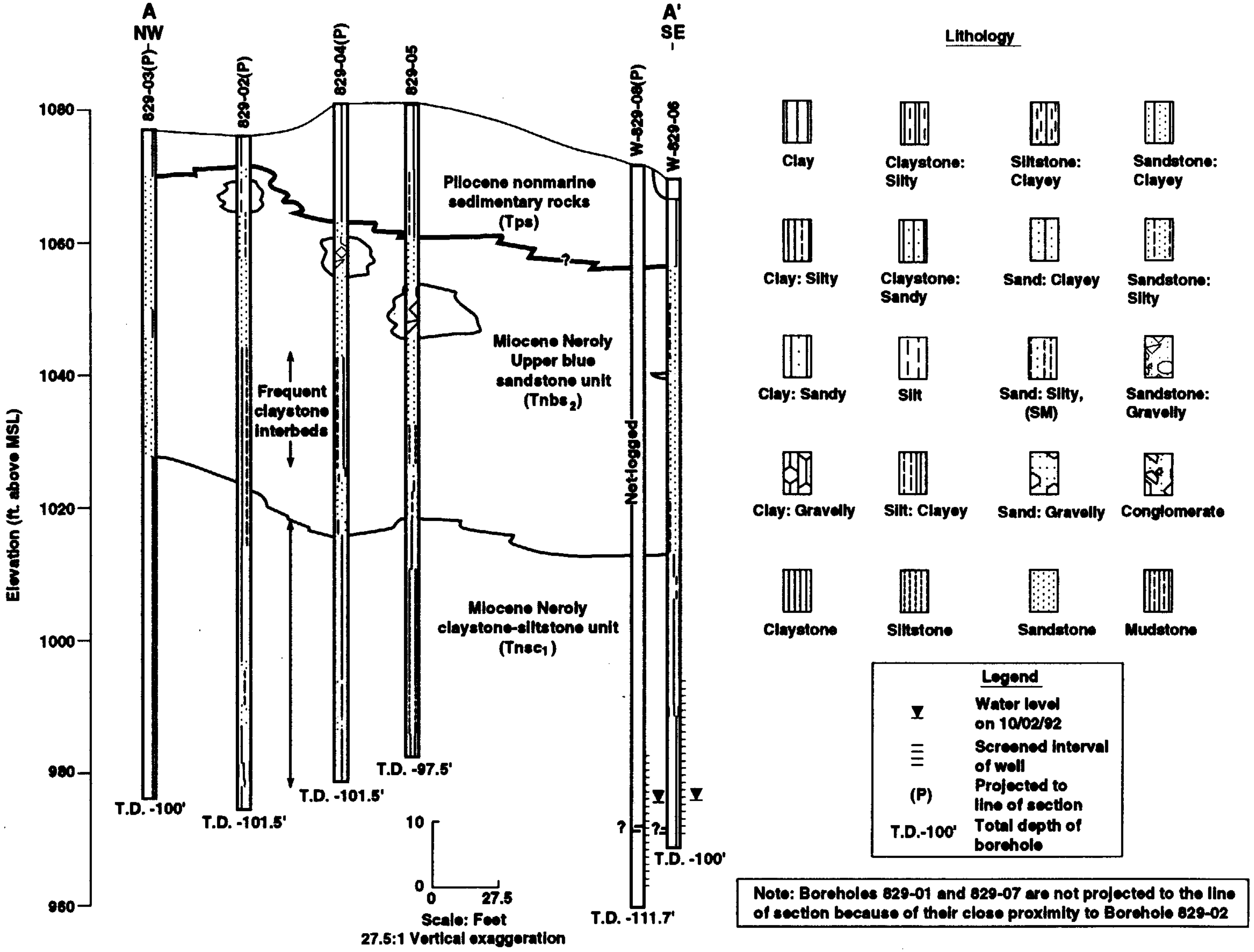

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Figure 1.4-5. Geologic cross-section A-A', Building 829 Complex, HE Open Burn Treatment Facility. Line of cross-section shown on Figure 1.2-4.

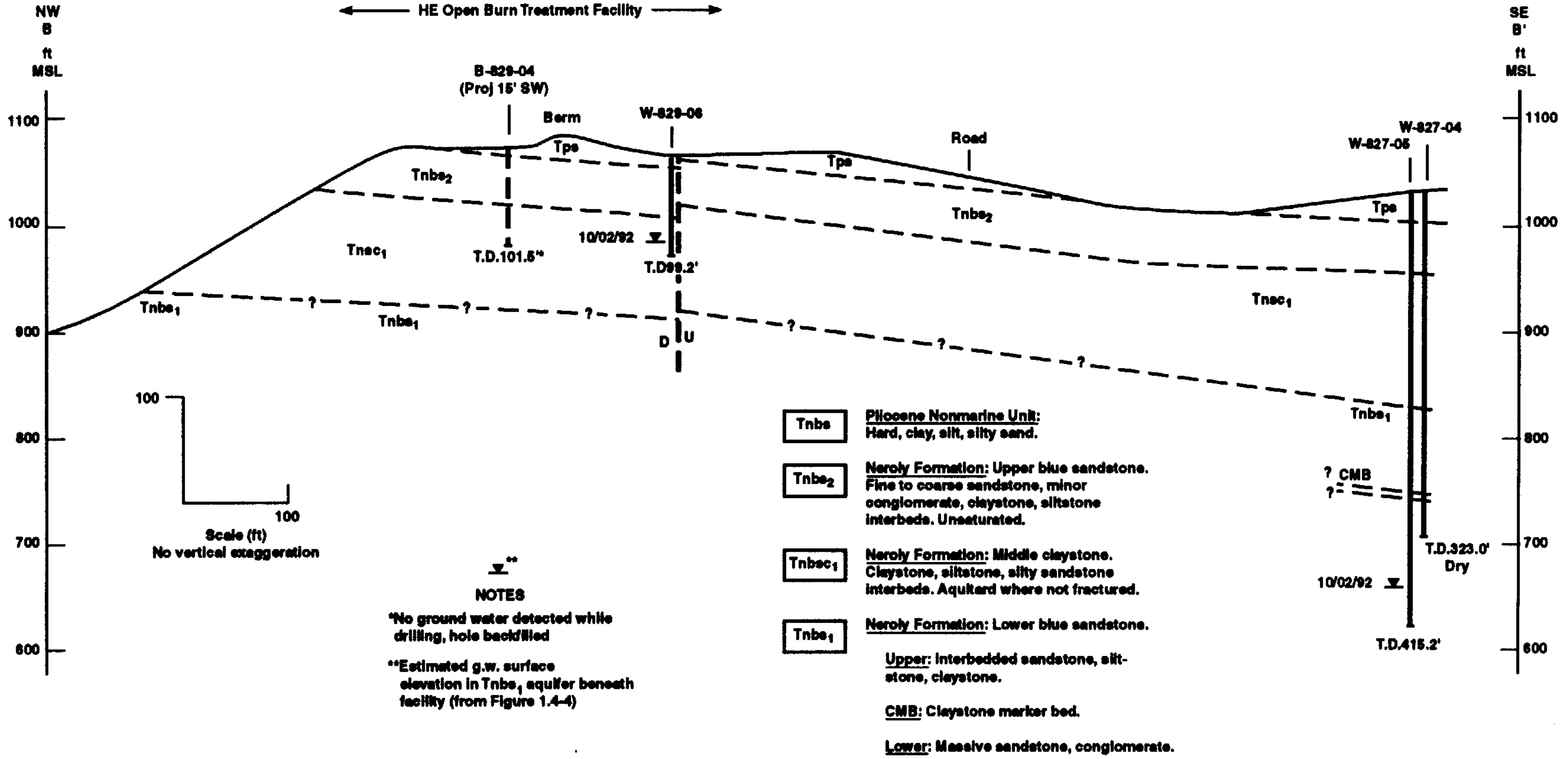

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Figure 1.4-6. Geologic cross-section B-B', Building 829 Complex area. Line of cross section shown on Figure 1.3-1.

A perched water-bearing zone lies beneath the HE Open Burn Treatment Facility below the 90-ft depth as evidenced by the presence of water in W-829-06 and W-829-08 (Fig. 1.4-7 and Table C-8). The perched aquifer is a fractured claystone, as opposed to the more common sandstone aquifers encountered at Site 300. The source of the water is not known. The perched aquifer is not present in the Building 828 Complex, which is on the same flank of the Patterson Anticline approximately 450 ft south and downgradient of the facility (Toney and Crow, 1989). The extent of the aquifer is not known but appears to be limited based on its absence at Building 828 and further downslope at the location where monitoring wells W-827-04 and W-827-05 were drilled. No discharge locations from this aquifer have been observed. The small fault projected to pass about 15 ft southeast of W-829-06 (Fig. 1.4-6) may limit the downgradient extent of the perched water-bearing zone.

The gradient within the perched aquifer most likely follows the south-southeastern dip of the claystone beds. The perched aquifer is separated from the regional aquifer monitored by well W-827-05 by more than 300 ft of Neroly Formation sediments that include interbeds of claystone and siltstone. Water levels measured in W-827-05 are included in Table C-8. As stated in section 1.3.3.3, no confirmed VOCs or explosives compounds have been detected in water samples obtained from well W-827-05.

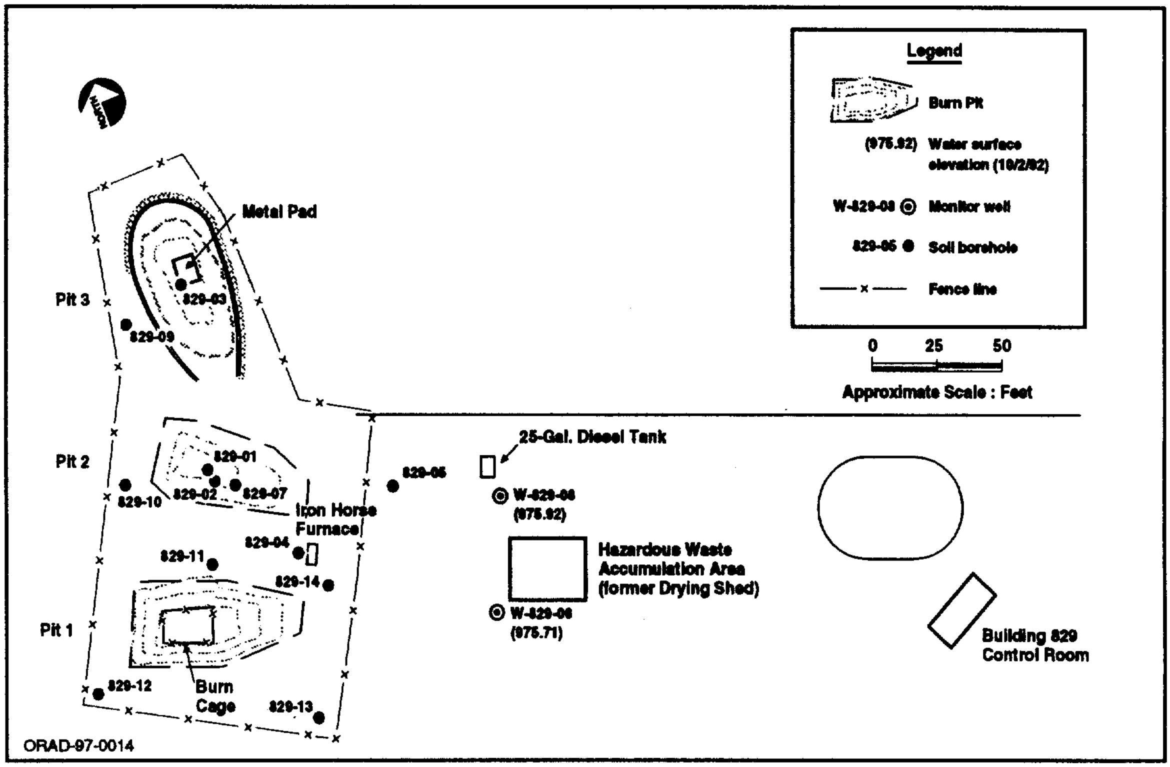

Figure 1.4-7. Ground water surface elevations, perched water-bearing zone.

1.4.4 Contaminant Fate and Transport Modeling

We analyzed ground water samples from wells W-829-06 and W-829-08 for VOCs and detected TCE concentrations of 700 µg/L (ppb) and 5 µg/L (ppb), respectively. Both wells are completed in a 1.7-ft-thick perched water-bearing zone in the Tnsc_1 siltstone/claystone unit approximately 90 ft below the surface (Figures 1.4-5 and 1.4-8).Field hydraulic data indicate the perched zone does not respond to seasonal precipitation. However, to be conservative, we used the one-dimensional numerical model VLEACH (U.S. EPA, 1990) to model the vertical (i.e., downward) migration of TCE from the perched water-bearing zone through the Tnsc_1 siltstone/claystone unit to the Tnbs_1 regional drinking-water supply aquifer via infiltrating rainwater (Figure 1.4-9).

VLEACH simulates the transport of volatile contaminants through unsaturated soil/rock of constant moisture content, via liquid advection, gaseous diffusion, and linear partitioning. VLEACH was first used at the Phoenix-Goodyear Superfund Site in Arizona to predict the transport of VOCs through the vadose zone to ground water.

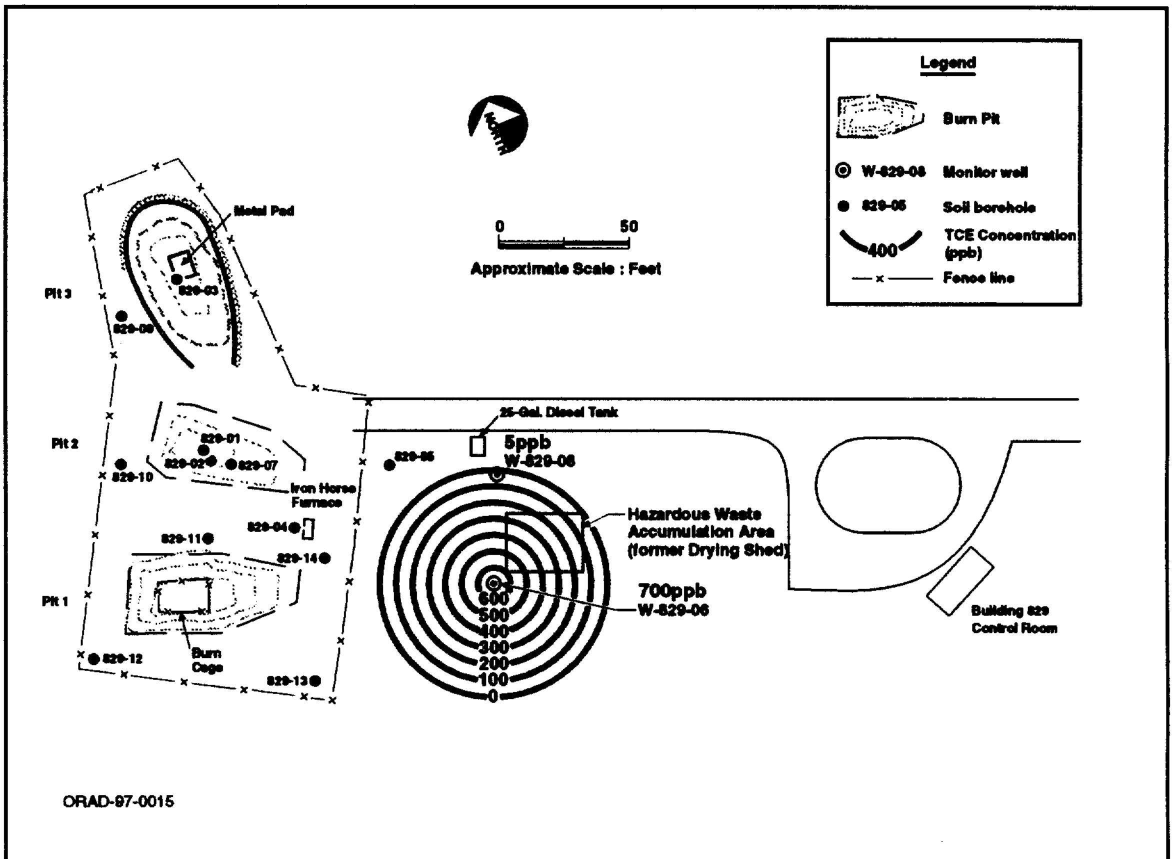

Figure 1.4-8. Area potentially impacted by TCE in ground water concentrations of 700 and 5 ppb in monitor wells W-829-06 and W-829-08, respectively. Building 829 Complex HE Open Burn Treatment Facility, LLNL Site 300.

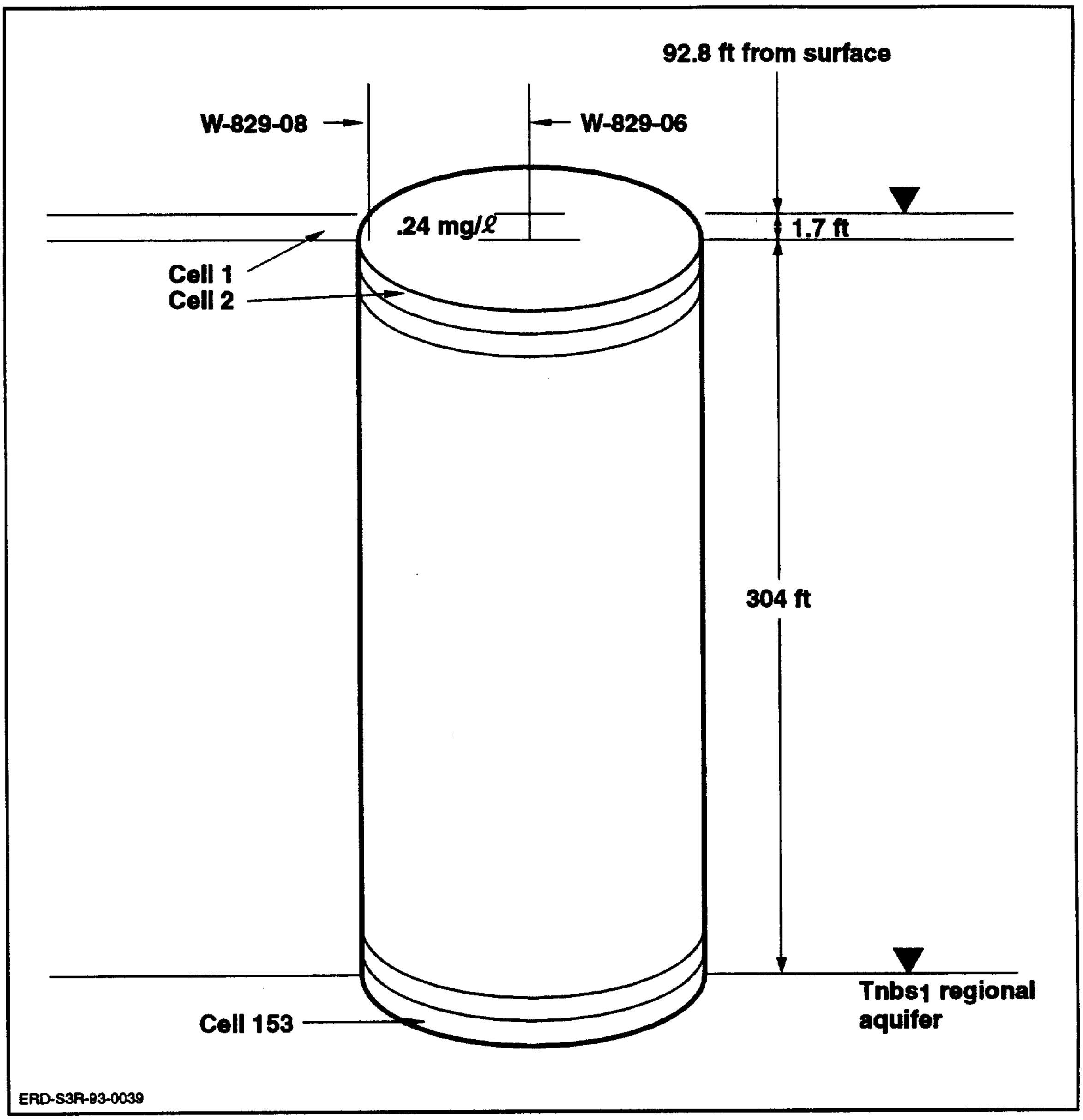

Figure 1.4-9. VLEACH model schematic for HE Open Burn Treatment Facility TCE fate and transport modeling.

1.4.4.1 Model Description

VOC transport is assumed to occur in the liquid and gas phases. Equations 1 and 2 describe one-dimensional contaminant transport in the liquid and gas phases, respectively. The processes include liquid phase advection as a result of downward seepage, vapor phase diffusion, partitioning (sorption) described by a linear equilibrium isotherm, and contaminant degradation in the liquid phase with first-order kinetics. Sorption slows solute transport relative to ground water flow and is represented by the retardation coefficient (R) in the transport equations.

$$R\frac{dC_l}{dt} = -v\frac{\partial C_l}{\partial z} - \lambda RC_l \qquad \text{(Eq. 1)}$$

$$R\frac{dCg}{dt} = D_{eff}\frac{\partial^2 Cg}{\partial z^2} \qquad \text{(Eq. 2)}$$

where

C_l = TCE concentration in the liquid phase [M/L^3],
C_g = TCE concentration in the gas phase [M/L^3],
D_{eff} = effective diffusion coefficient [L^2/T],
R = retardation factor,
v = vertical or seepage velocity (or recharge rate) [L/T],
z = vertical depth variable [L], and
λ = degradation rate constant [1/T].

Equation 3 describes the vapor-diffusion coefficient (D_v) as a function of the total (n) and water-filled (θ) porosity and the free-air diffusion coefficient (D_{air}). Equation 4 describes the effective diffusion coefficient in terms of the vapor-diffusion coefficient (D_v); it incorporates retardation due to linear, equilibrium partitioning.

$$D_v = D_{air}\frac{(n-\theta)^{10/3}}{n^2} \qquad \text{(Eq. 3)}$$

$$D_{eff} = HD_v[\rho_b K_d + \theta + (n-\theta)H] \qquad \text{(Eq. 4)}$$

where

D_{air} = vapor diffusion coefficient for air [L^2/T],
D_v = vapor diffusion coefficient [L^2/T],
D_{eff} = effective diffusion coefficient [L^2/T],
K_d = liquid/solid partition coefficient [L^3/M],
H = Henry's law constant,
n = total porosity,
θ = water-filled porosity (volumetric water content), and
ρ_b = bulk density [M/L^3].

The modeled region can be divided into distinct soil columns that may differ in soil properties, recharge rate, etc. In each column, the soil/rock is assumed to be completely homogeneous with no preferential pathways to flow. Each column is divided into cells of uniform thickness. A depth-concentration profile can be generated by specifying the initial aqueous-phase concentrations for each cell along a simulated soil column. The boundaries at the upper and lower ends of the simulated column may be specified either as being impermeable to contaminant flux from the system (zero flux boundary), or as each having a constant contaminant concentration (constant concentration boundary).

A contaminant, present in infiltrating water, may enter the soil column at a specified initial concentration and a constant recharge/infiltration rate for an infinite source, or enter by placing the known mass in the cells for a finite source. The model assumes equilibrium between the solid, liquid, and gas phases and redistributes the contaminant mass in each phase after every time-step. At the end of the simulation, the model predicts a flux of contaminant to ground water and generates a profile of contaminant concentration vs depth for each of the three phases. The source code was modified to include an aqueous-phase decay term that accounts for contaminant degradation.

VLEACH is a one-dimensional code and cannot accurately simulate what may be a three-dimensional system. However, more detailed, higher-dimensional models would probably result in longer flow paths and peak concentrations arriving in ground water at a later time. VLEACH is conservative in that it considers the shortest possible transport path. Details on the model, the initial and boundary conditions, and the input parameters are included in the VLEACH manual (U.S. EPA, 1990).

1.4.4.2 Potential Areal and Vertical Extent of TCE

Using December 1992 data, we estimated the areal extent of TCE in ground water to be 5026 ft^2. This was determined by assuming the highest detected concentration, 700 µg/L (ppb), to be the center of the contaminated area and the lower detected concentration, 5 µg/L (ppb), to define the radial decline in concentration (Figure 1.4-8). Our method produces an areal extent of contamination defined by a circle with a radius of 40 ft.

To calculate an average concentration for this area, we calculated an area weighted average by linearly interpolating contours (circles) of concentration between the center point and the zero concentration contour. We multiplied the average concentration between contours by the area between contours, summed these values, and divided by the total area (5026 ft^2). This produced an average concentration of 240 µg/L (ppb). This is a health-conservative approach because concentrations usually decrease logarithmically, not linearly. If we had taken a logarithmic approach, the average concentration would be an order of magnitude lower.

We calculated vertical transport distance by taking the distance from the top of the perched water-bearing zone to the top of the water table (i.e., saturated portion) in the $Tnbs_1$ regional aquifer (Figure 1.4-6). The thickness of each unit is about 66 ft for the $Tnsc_1$ and 240 ft for the $Tnbs_1$, for a total of 306 ft. Figure 1.4-9 shows a schematic of the cylindrical column defined by the areal extent and potential vertical extent that are being modeled.

1.4.4.3 Geologic Description of the Column

The column we are modeling contains a combination of interbedded sandstone, siltstone, and claystone of the $Tnsc_1$ and $Tnbs_1$ Neroly units. Because the model treats the column soil/rock properties as homogeneous, we chose the health-conservative values that represent sandstone. The transmissive properties of sandstone encourage contaminant transport, resulting in higher concentrations in less time at the modeling endpoint. A more detailed discussion on the geology of the HE Open Burn Treatment Facility area is in section 1.4.3.

1.4.4.4 Modeling of the Column

The column is divided into 153 cells of 2 ft thickness each (Figure 1.4-9). The first (i.e., uppermost) cell is representative of the perched water-bearing zone. Because the water-bearing zone is only 1.7 ft thick, the concentration in the first cell is adjusted for the slightly bigger thickness of 2 ft and the lower volumetric water content of 0.17 (from 240 to 300 µg/L [ppb]). Because we have a finite contaminant (TCE) source, the total mass of TCE is characterized in the first cell. The contaminant source normally fluxing into the first cell is set to zero.

1.4.4.5 Input Parameters for VLEACH

Tables 1.4-1, 1.4-2, and 1.4-3 display the values selected as input parameters for our modeling. Discussion of sensitivity analyses is presented in Appendix G.

Table 1.4-1. Soil/rock properties used in modeling TCE transport to the Tnbs$_1$ regional aquifer in the HE Open Burn Treatment Facility study area.

Input parameter	Value	Comments
Porosity (n)	0.25 (dimensionless)	Based on sonic logs and previous determinations (Bryn *et al.*, 1990).
Bulk density (ρb)	2.0 gm/cm^3	Simulated column is assumed to be homogeneous, uniform sandstone with a solid density of 2.65.
Volumetric water content (θ)	0.17 (dimensionless)	Estimated from neutron geophysical log data obtained from the Building 834 area to the north (Madrid, 1991).
Organic carbon content (f_{oc})	0.001 (dimensionless)	F_{oc} for Neroly Formation is estimated to be 0.1% (Bryn *et al.*, 1990).

Table 1.4-2. Chemical properties used in modeling TCE transport to the Tnbs$_1$ regional aquifer in the HE Open Burn Treatment Facility study area.

Chemical property	Value
Organic partition coefficient (K_{oc})	98 mL/gm
Henry's law constant (H')	0.44 (dimensionless)
Aqueous solubility (C_{max})	1,100 mg/L
Free-air diffusion coefficient (D_a)	0.43 m^2/day
Decay half-life ($t_{1/2}$)	50 yr

Table 1.4-3. Input parameters used in modeling TCE transport to the $Tnbs_1$ regional aquifer in the HE Open Burn Treatment Facility study area.

Input parameter	Value
Number of polygons	1
Polygon area	5026 ft^2
Number of cells	153
Cell thickness	2 ft
Calculation time-step	5 yr
Simulation time	1295 yr
Ground water recharge rate (Q)[a]	0.09 ft/yr
Infiltrating concentration (C_{inf})	0 mg/L
Atmospheric concentration (C_{atm})	0 mg/L
Initial Ground water concentration for cell 1 (C_{gw})[b]	0.30 mg/L
Initial Ground water concentration for cells 2 through 113 (C_{gw})	0 mg/L
Initial Ground water concentration for the regional aquifer (C_{gwr})	0 mg/L
Partition coefficient[c]	0.098 mL/gm
Retardation factor[d]	1.8 (dimensionless)
Decay coefficient[e]	0.014 per year

[a] 10% of the average annual rainfall at Site 300 from 1965 to 1975 (11 in./yr).

[b] A total TCE concentration of 120 $\mu g_{TCE}/kg_{H_2O}$ was used to achieve the 0.30-mg_{TCE}/L_{H_2O} concentration in the liquid phase for the first cell.

[c] $K_d = K_{oc} * f_{oc}$

[d] Retardation factor, $R = 1 + \rho_b (K_d/n)$

[e] Decay coefficient = $0.693/(t_{1/2})$

1.4.4.5.1 Porosity (n) and Bulk Density (ρb). The soil/rock properties (Table 1.4-1) of porosity and bulk density have conservative values of 0.25 (dimensionless) and 2.0 g/cm^3. These values are consistent with properties of sandstone listed in Freeze and Cherry (1979).

1.4.4.5.2 Decay Half-Life ($t_{1/2}$). The model is run with two different TCE decay parameters: no decay and 50-year half-life decay (Table 1.4-2). The 50-year TCE half-life was chosen based on information presented in Layton *et al.* (1990).

1.4.4.5.3 Recharge (Q). We assumed a recharge rate of 10% of the average annual precipitation rate (11 in./yr) recorded at Site 300 between 1965 and 1975 (Table 1.4-3). This value was arrived at by two independent sources, Raber and Carpenter (1983) and Webster-Scholten, Ed. (1993).

1.4.4.5.4 Infiltration (C_{inf}), Ground Water (C_{gw}), and the Regional Aquifer (C_{gwr}) Concentrations. Except for the first cell, we assume the recharge water, the soil/rock column, and regional aquifer to be free of TCE at time t = 0 (Table 1.4-3).

1.4.4.5.5 Atmospheric Concentration (C_{atm}). Another of our health-conservative measures is to disallow any upward gas diffusion. This forces all contaminant mass to migrate vertically downward, thus increasing the concentrations that reach the regional aquifer.

1.4.4.6 Results

Predicted TCE concentrations reaching the $Tnbs_1$ regional aquifer do not exceed the Federal MCL of 5 µg/L (ppb) (code of Federal Regulations Parts 141 and 142). The predicted maximum concentration to reach the regional $Tnbs_1$ aquifer is 6.6×10^{-20} µg/L (ppb) after 115 years with decay (Figure 1.4-10), and 3.4 µg/L (ppb) after 1295 years without decay.

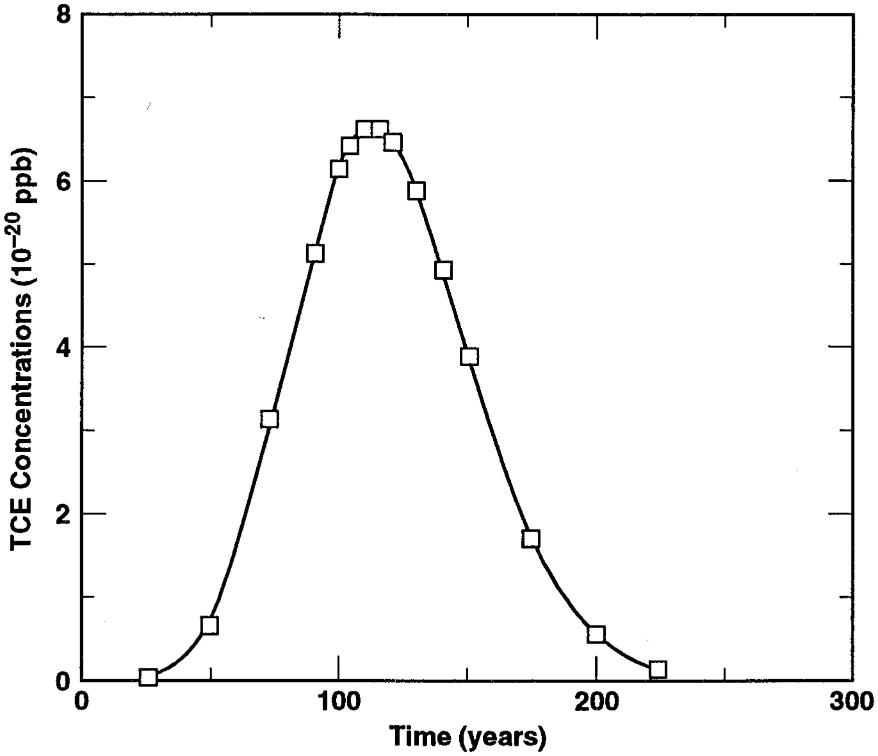

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Figure 1.4-10. TCE concentrations reaching the regional aquifier (base case).

These predicted TCE concentrations are health-conservative. This is because we have only modeled to the regional aquifer. The nearest water-supply well, Well 20, is 6140 ft downgradient of our modeling endpoint (Figure 1.1-2). Added transit time, decay, and dilution would further reduce concentrations by one or more orders of magnitude, by the time our predicted concentrations would reach Well 20.

There are several other reasons to consider these predicted concentrations to be health-conservative:

- TCE transport is modeled only vertically—it does not take into account horizontal dispersion.
- Soil/rock column is modeled as sandstone—it does not take into account heterogeneity that would slow transport time, allowing for more decay to take place.

- Conservative contaminant mass estimate—estimates are perhaps an order of magnitude higher than the most likely case.
- Assume infiltration to 90 ft depth—it is probable that infiltration may decrease significantly with depth due to the low-permeable soil/rock present above the perched water-bearing zone.
- Upward gas diffusion is disallowed—this forces all the TCE mass to migrate downward, which may not be totally representative of the most likely case.

Based on our conservative selection of parameters and the transport and fate that would occur downgradient of our modeling endpoint, the model most likely overpredicts TCE concentrations reaching the regional aquifer.

1.4.5 Age of Ground Water

A mean residence time (MRT) raw ^{14}C age of 13,610 ± 70 yr BP (before present) has been determined for ground water from the regional $Tnbs_1$ aquifer in monitor well W-827-05 (Beta Analytic, Inc., 1993). This latest Pleistocene MRT age is based upon ^{14}C activity of carbonate dissolved in the water.

The calculated age of the water sample obtained from W-827-05 is not an absolute age as would be determined, for instance, for a bone or wood fragment because ground water is not typically a closed system. However, the relative age of the W-827-05 water sample clearly indicates little mixing of geologically recent ground water with older recharge water. This indicates that the regional $Tnbs_1$ aquifer beneath the HE Open Burn Treatment Facility is largely isolated from the surface environment. This observation provides additional independent support to the conclusion reached in section 1.4.4 based on TCE transport modeling that contamination of the regional aquifer by TCE at concentrations approaching the MCL should not be anticipated.

1.4.6 Seismic Hazard Assessment

Seismic hazard appraisals of LLNL Site 300 have been provided by Raber and Carpenter (1983), Tera Corporation (1983) and Carpenter *et al.* (1991). A recent regional study by Wentworth and Zoback (1989) also provides relevant data.

These studies indicate that the HE Open Burn Treatment Facility may experience earthquake shaking from three general sources. These sources are the following:

- A major earthquake on a principal Bay Region fault.
- A strong earthquake generated by a local fault within the Altamont Hills.
- A major earthquake on a regional fault along the Coast Ranges–Central Valley boundary or possibly beneath the western portion of the San Joaquin Valley.

As noted in section 1.4.1, the nearest potentially active fault to the HE Open Burn Treatment Facility is the Corral Hollow–Carnegie Fault Zone located about 1 mile to the southwest. As discussed in Carpenter *et al.* (1991), the presence of likely Holocene activity within the Corral Hollow–Carnegie Fault Zone suggests that the zone itself is potentially active and capable of generating a maximum probable earthquake of about

$M_S = 6.5$. Such an earthquake could cause very strong ground motions at the HE Open Burn Treatment Facility site but does not pose a potential ground rupture hazard to the facility.

The local fault previously described is of insufficient extent to represent an independent seismic source, although minor fracturing might occur sympathetically along it during a major regional earthquake.

Strong earthquake ground motions could cause sloughing of soil and decomposed rock from the face of the cut slope located along the easterly side of the HE Open Burn Treatment Facility. This debris would fall onto the top cover but would not contain any large rocks that could penetrate the cover. Strong ground shaking could also generate minor landslides on steep natural slopes northwest and southeast of the facility, particularly if these slopes were saturated by seasonal rainfall.

Because the HE Open Burn Treatment area is underlain by dense claystone and sandstone rock, liquefaction and related ground failure phenomena are not potential hazards to the facility.

In the event of a moderate to major earthquake, the cover and drainage diversion ditches would be inspected by the LLNL Site 300 Plant Engineering personnel for evidence of disturbance. Remedial grading, removal of debris from drainage ditches, or slide repair would be undertaken if deemed necessary.

1.5 Final Closure of HE Open Burn Treatment Facility

1.5.1 Final Closure Activities [22 CCR 66265.112(b)(1) and 40 CFR 265.112(b)(1)]

The closure of the HE Open Burn Treatment Facility will be accomplished in the following manner: (1) establishing project team, (2) final treatment and ash removal, (3) facility demolition and removal, (4) site capping and grading, and (5) soil sampling and monitoring well installation. Detailed technical specifications of the closure are presented in Appendix D. Construction quality inspection methods are described in Appendix E.

All personnel working on this project must follow the policies set forth in this plan as well as LLNL and DOE policies, procedures, and instructions, particularly LLNL's *Health and Safety Manual* (LLNL, 1991) and the *Site 300 Safety and Operational Manual* (LLNL, 1989b). Subcontractors must develop their own health and safety procedures, which may be modeled on those provided by LLNL. Procedures developed by subcontractors must be reviewed and approved by the Environmental Restoration Site Safety Officer (ERSO) prior to the initiation of work.

1.5.1.1 Establish Project Team

LLNL will establish a project team to manage and implement the closure of the HE Open Burn Treatment Facility. The composition of the project team is described in detail in section 1.5.3. Major actions include: retaining an independent professional engineer; assigning an LLNL design engineer, an LLNL project coordinator, and an LLNL construction manager; designating construction quality assurance (CQA) inspectors. This team will work throughout the closure process to document and verify all closure activities. At the conclusion of the closure activities, the team will submit closure reports to regulatory agencies, add a notice to the deed, and certify closure.

1.5.1.2 Final Treatment and Ash Removal [22 CCR 66265.381 and 40 CFR 265.381]

All explosives wastes will be treated and the resulting ash removed from the HE Open Burn Treatment Facility prior to the date of closure according to the B-829 ash removal procedure.

1.5.1.3 Facility Demolition and Removal

The following equipment at the HE Open Burn Treatment Facility will be dismantled and managed as indicated.

1. The Iron Horse burn unit will have the diesel lines and firing circuits disconnected. Small parts, including the burner and the screens, will be removed and loaded into a roll-off bin for transport to a secure chemical landfill. The rest of the Iron Horse will be decontaminated by steam cleaning using a solution of trisodium phosphate. All steam-cleaning residue and rinsate will be collected and handled as described below. Decontamination will be verified by one random wipe sample. The decontaminated unit will be held for disposition as non-hazardous material. If decontamination of the Iron Horse proves impracticable, it will be loaded into a roll-off bin for transport to a secure chemical landfill.

2. The Pit 1 burn cage will be dismantled using either a cutting torch or a saw. The resulting pieces will be loaded into a roll-off bin for transport to a secure chemical landfill.

3. The Pit 3 steel firing plate will be decontaminated by steam cleaning using a solution of trisodium phosphate. All steam-cleaning residue and rinsate will be collected and handled as described below. Decontamination will be verified by one random wipe sample. The decontaminated plate will be held for disposition as non-hazardous material. If decontamination of the firing plate proves impracticable, it will be loaded into a roll-off bin for transport to a secure chemical landfill.

4. The firing circuits will be disconnected and the conduit excavated and removed from the burn units back to beyond the lateral extent of the site cap. The conduit will be loaded into a roll-off bin for transport to a secure chemical landfill.

5. The fence will be dismantled. The parts will be held for disposition as non-hazardous material.

Collected steam-cleaning residue and rinsate will be sampled and analyzed for hazardous constituents. If the waste water is nonhazardous and meets discharge requirements set by the City of Livermore Water Reclamation Plant, it will be transported to the LLNL Livermore site for discharge to the sanitary sewer. If the wastewater is hazardous and/or does not meet discharge requirements, it will be transported to an approved offsite facility for treatment and/or disposal.

1.5.1.4 Site Capping and Grading

A cap will be constructed according to design specifications (Appendix D) to cover all three pits and the Iron Horse site. The cap will include a foundation layer, low-permeability layers, and a final cover (topsoil and vegetative) layer. During the construction of the cap, required inspections of the cap components and field testing will be performed by the inspection team. All work and testing will be overseen by the construction manager (CM) and subject to review by the independent professional engineer. They include the following:

1. Designated borrow soils for the various layers of the cap will be identified and tested.
2. The site will be graded to specifications to prepare for addition of the foundation layer.
3. A foundation layer made of local soil from designated borrow area(s) will be placed in the pits and on top of the pit area to achieve the specified grade.
4. The low-permeability layer will be constructed of 2 layers: (1) an upper 60-mil-thick HDPE membrane and (2) a lower 0.18-in.-thick geosynthetic layer impregnated with bentonite clay. The saturated hydraulic conductivity of the geosynthetic layer will be 1×10^{-7} cm/s or less. Permeability will also be verified by inspection and manufacturer's product information and warranty. The membrane will also meet strict geotechnical specifications.
5. A 0.28-in.-thick geosynthetic drainage layer will be installed on top of the low permeability layer.
6. The final topsoil cover will be at least 2 ft thick and the soil will be obtained from an onsite source.
7. Runoff controls from the cap and from the adjacent hillside will be constructed.
8. The final vegetative cover will be hydroseeded between October 1 and November 15, as recommended by the U.S. Department of Agriculture.

1.5.1.5 Soil Sampling and Monitoring Well Installation

Soil samples will be collected from the HE Open Burn Treatment Facility area prior to capping and grading activities. The areas of pits 1, 2, and 3 will be gridded and two grids selected randomly for each pit. Four soil samples will be collected from the selected grids at the following depths: (1) at the surface, (2) at about 2-ft depth, (3) at about 5-ft depth, and (4) at 10-ft depth. The remaining B-829 Treatment area will be separately gridded, and eight randomly selected grids will be sampled with samples collected at the surface. The samples will be collected in compliance with Site 300 Environmental Restoration Standard Operating Procedures (SOPs). Both TCLP and WET extraction procedures will be used and the leachate will be analyzed for the constituents of concerns identified in Chapter 2.

One additional monitoring well will be installed for post-closure monitoring at the approximate location shown on Figures 1.3-1 and 2.4-1. The proposed monitoring well location was selected based on the potentiometric surface map (Figure 1.4-4) and field considerations, such as rig access and impact on other Site 300 activities. The well will be completed to monitor the regional aquifer.

The proposed site for the new monitor well is on a flat area resulting from the former presence of a long abandoned fire trail. The surface material consists of clay (geologic unit Tps). The site is hydraulically downgradient from the B-829 facility with an easterly component. A well about 450 feet deep would be required to reach the regional aquifer at this location. An alternate location is available about 50 feet southwest of the primary site. The well will be constructed to meet the specifications described in section 2.4.3. The well will be logged and developed in accordance with SOP No. 1.

Since the publication of the draft closure plan in 1993, a new monitor well, W-829-15, was installed adjacent to the parking area for Building 828 (B-828), north of the road to B-828. It is nearly level with a hard pebbly sandstone exposed at the surface. The site is hydraulically downgradient from the B-829 facility and hydraulically upgradient from B-828. The well was screened in the regional aquifer.

1.5.2 Closure Performance Standard [22 CCR 66265.111 and 40 CFR 265.111]

Specific measures to fulfill the requirements of 22 CCR 66265.111 and 40 CFR 265.111, "Closure Performance Standard," are described in sections 1.5.2.1 and 1.5.2.2 and fulfill the following conditions:

1. Minimize the need for further maintenance.
2. Control, minimize, or eliminate, to the extent necessary to protect human health and the environment: post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated run-off or hazardous waste decomposition products to the ground, surface waters, or the atmosphere.
3. Comply with the closure requirements for interim status thermal treatment units [265.381].
4. Follow procedures specified in the Site Safety Plan (Appendix I).

1.5.2.1 Closure Performance Standard Compliance

As required for closure of a thermal treatment unit [22 CCR 66265.381 and 40 CFR265.381], this closure plan (sections 1.5.1.2 and 1.5.1.3) provides for the removal of all hazardous waste and hazardous waste residues, including ash and the treatment facility hardware. The removed materials will be managed as hazardous wastes, in accordance with applicable requirements. The removal of these materials eliminates the possibility of post-closure escape of hazardous waste and reduces the need for further maintenance. Some soil contamination does exist at this site from past operation at the HE Open Burn Treatment Facility. Capping and grading the facility will prevent the migration of contaminants due to leaching and will prevent contamination of surface run-off.

1.5.2.2 Capping and Grading

This closure plan provides for capping and grading the burn pits. Other options, including clean closure, were considered. Capping and grading were selected based on careful considerations of site location, topography, geologic and hydrologic factors, climate, cover characteristics, type and amount of wastes, and the potential for contaminant migration. Capping and grading achieve the goal of protecting human health and the environment, while retaining the natural integrity of the area.

Capping and grading effectively prevent threats to human health and the environment for the following reasons:

1. Once the capping and grading are completed, routine maintenance will consist of periodic monitoring to verify the integrity of the cap (section 1.6.5).
2. Capping the area will prevent percolation through the contaminated soil to minimize and control the creation of leachate (section 1.6.4).
3. Capping prevents direct contact between stormwater run-off and the contaminated soils.
4. Grading will divert stormwater run-off around the capped area to minimize erosion of contaminated soils and will prevent contamination of surface water (section 1.6.4).
5. Capping is also a barrier to direct contact between wind and the contaminated soils to prevent contaminated soils from becoming airborne dust contamination.

Although also considered, clean closure is not proposed because removing and transporting thousands of cubic yards of materials that contain very low concentrations of contaminants would destroy the natural integrity of the area, and the financial and environmental costs would be excessive. Both the capping and grading option and the clean closure option would achieve the goals of the Closure Performance Standard. Capping and grading of the burn area provides a more cost-effective corrective measure alternative.

1.5.3 Project Team Organization

A clearly delineated organizational structure for the team members of the project provides effective management of the final closure process. The proposed organizational structure is depicted in Figure 1.5-1, which graphically shows the hierarchy and lines of authority between the design/construction team members. The individual responsibilities and authorities of the project team members are defined in this section.

1.5.3.1 Regulatory Agencies

The DTSC, the RWQCB, and the EPA are the permitting agencies for the closure plan. The regulatory staff reviews the proposed closure and post-closure plans and the CQA plan for compliance with the agency regulations.

The DTSC will act as lead agency in the permit review process. The DTSC staff will review the closure documents, send Notices of Deficiency (NOD) if required, and either approve or modify the closure plan. Once the plan is approved, the regulatory agencies will review any submitted design changes that are proposed during the construction period.

Upon completion of construction, the aforementioned regulatory agencies will receive from the appropriate team members all required documents related to the closure construction, including, but not limited to, survey plats, interim and final construction quality control reports, required certifications, and post-closure inspection documents.

1.5.3.2 Independent Professional CQA Engineer

An independent professional CQA engineer (PE) retained by LLNL will provide independent review of the closure activities and associated reports and documents. The independent professional engineer will be a licensed civil engineer who is currently registered within the State of California.

1.5.3.3 Lawrence Livermore National Laboratory

As the design engineer and project coordinator of the hazardous waste facility, LLNL will have the following responsibilities:

1. Provide access necessary to complete the construction work, including, but not limited to, security checks, passes, etc.
2. Provide all historical site documentation and records of hazardous waste treatment and contaminant monitoring necessary to implement the construction project.
3. Provide an environmental restoration safety officer (ERSO), a health and safety plan, and educate the project and contractor's personnel on the required health and safety procedures.
4. Prepare design plans, drawings, and specifications for the construction project.
5. Authorize any change orders to the contractor's scope of work.

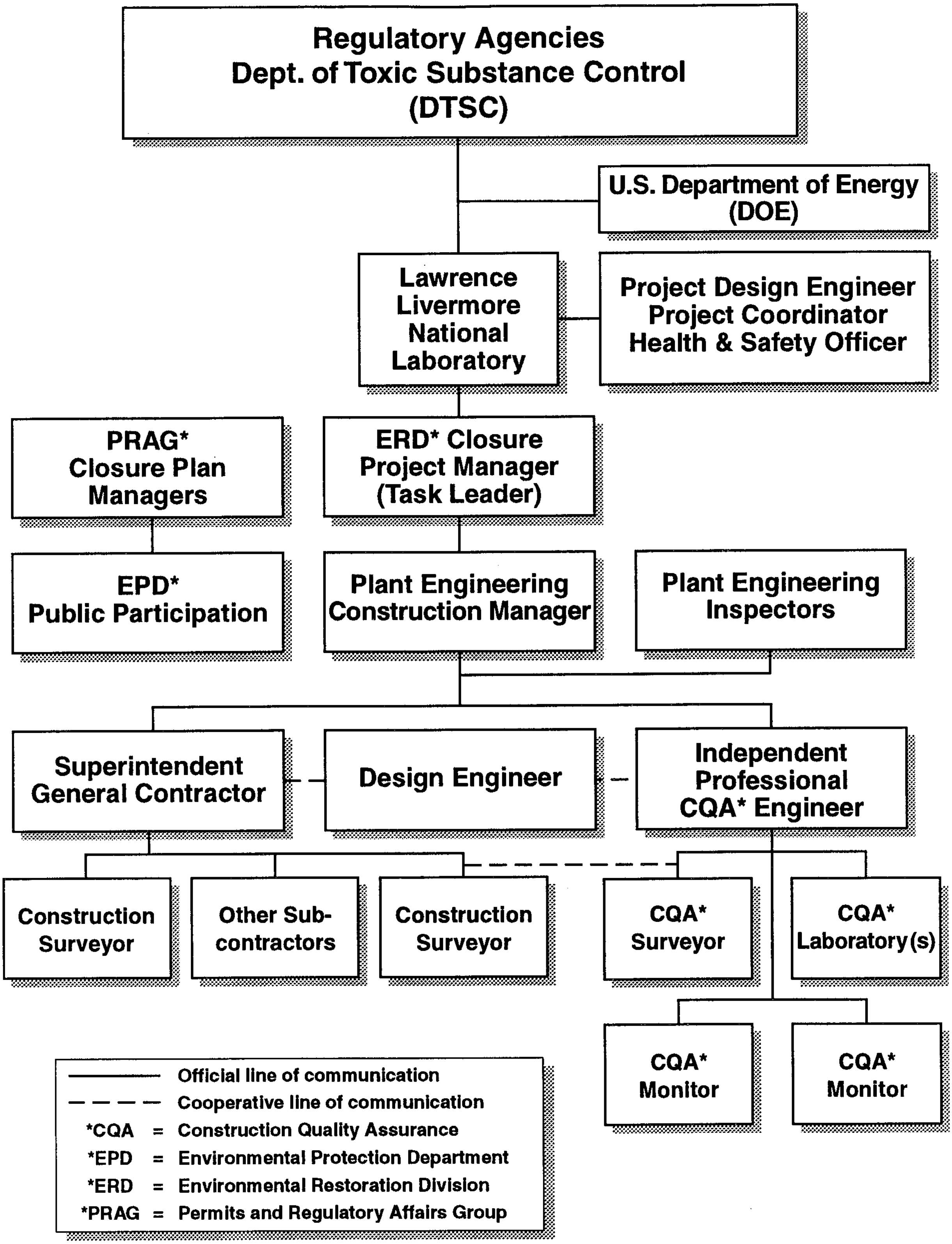

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Figure 1.5-1. Project team organization, HE Open Burn Treatment Facility closure, Site 300, LLNL.

6. Authorize and process the contractor's progress billings.
7. Coordinate any design changes with the CM and with the regulatory agencies.
8. Respond to any requests from the CM on clarification of design details or specifications during construction.
9. File necessary certifications and notices with the regulating agencies.
10. Prepare a post-closure plan and schedule the accompanying inspections.
11. Supply the regulating agencies with all documents required to assure the agencies that the work is being completed in accordance with the approved design plans, drawings, and specifications.
12. Review CQA activities and reports.

LLNL has the authority to select and dismiss entities assigned to CQA and construction activities. LLNL also has the authority to accept or reject CQA plans, progress reviews and recommendations of the CM, and the materials and workmanship of the contractor.

1.5.3.4 Construction Manager

1.5.3.4.1 CM Responsibilities. The responsibilities of the CM will include the following:

1. Review design drawings and specifications for clarity and completeness.
2. Serve as LLNL's liaison with the construction contractor in interpreting and clarifying project drawings and specifications.
3. Educate construction and inspection personnel on job requirements.
4. Schedule site inspections and surveys.
5. Manage and support the inspection staff in performing observations and tests by:
    a. Submitting blind samples for analysis by the inspection staff at one or more independent laboratories.
    b. Confirming that the testing equipment, personnel, and procedures do not change over time, or making sure that any changes do not result in a deterioration of the inspection process.
    c. Confirming that test data are accurately recorded and maintained.
    d. Verifying that the raw data are properly summarized and interpreted.
6. Provide to LLNL reports on the inspection results, including:
    a. Reviews and interpretations of observation records and test results.
    b. Identification of work that the CM believes should be accepted, rejected, or uncovered for observation, or that may require special testing, inspection, or approval.

   c. Reports that reject defective work and specify corrective measures.

7. In conjunction with LLNL, interview potential contractors for prequalification of bidders.
8. Prepare and update the schedule for the project.
9. Schedule the necessary project meetings, including the following:
   a. Preconstruction meetings, including site safety orientation meetings.
   b. Project progress meetings.
   c. Problem resolution meetings.
   d. CQA inspection staff meetings.
10. Review the contractor's progress billings and accompanying documentation for the amount of work completed to date.
11. Review change orders to the contractor's scope of work.

1.5.3.4.2 Qualifications. The CM for the project will be required to demonstrate the following qualifications:

1. Be a currently registered professional engineer, civil engineer, or certified engineering geologist in the State of California.
2. Have a minimum of five years experience in quality control related to earthwork/excavation construction.
3. Possess the management skills and experience necessary for the control of all CQA activities.
4. Have a bachelor's or master's degree in the field of civil engineering, geology, or engineering geology from an institution of higher learning approved by the Accreditation Board for Engineering and Technology.
5. Possess good oral and written communication skills.

1.5.3.5 Construction Quality Assurance Inspectors

The CQA inspector will be selected in accordance with the EPD QAMP and the EPD QIP 18.2 Requirements for Qualifications of Persons Performing Quality Assessments. Section 10 (Inspection), Section 11 (Test Control), Section 12 (Control of Measuring and Test Equipment), and Section 14 (Inspection, Test, and Operating Status) of the EPD QAMP cover the activities of the CQA inspector.

1.5.3.5.1 Responsibilities. CQA inspectors will be selected by LLNL from the existing Plant Engineering personnel. They will receive their assignments and report directly to the project CM. The responsibilities of the CQA inspectors will include the following:

1. Verify that the equipment used in testing meets the test requirements and that the tests are conducted according to standardized procedures.
2. Perform onsite inspection of the work in progress to assess compliance by the contractor with the project design criteria, plans, and specifications.
3. Report to the contractor results of all observations, tests, and work progress, and interact with the contractor to provide assistance in modifying the materials and work to comply with the specified design.
4. Report daily to the CM results of all inspections, including work that is not of acceptable quality or that fails to meet the specified design.

1.5.3.5.2 Requisite Qualifications of CQA Inspectors. CQA inspectors providing construction observation and testing services for the project will be formally trained in a program prepared by the CM to provide the field testing outlined in Appendix E, "Inspection Methods" (Table E-1), and in accordance with the testing procedures listed in Table E-2, "Test Procedures."

All CQA inspectors providing density and moisture testing of the compacted fill materials, using nuclear density testing gauges, will receive training in the handling of portable devices for low-millicurie measurements. The training will be conducted in a class that satisfies the requirements mandated by the Nuclear Safety Act. This class shall include the following topics:

1. Principles of radiation safety and health physics;
2. Principles of nuclear physics relative to moisture and density measurement of soils;
3. The safe and legal use, including licensing and compliance with regulations, of portable instruments containing radioisotopes;
4. Lab and field applications of instruments;
5. Instrument calibration;
6. Field service and maintenance of equipment.

Prior to performing any work on the project sites, the CQA inspection staff will receive training on health and safety issues from the LLNL Site 300 Health and Safety Officer.

1.5.3.6 Independent Laboratory

Prior to construction, a geotechnical laboratory, independent of LLNL, will be selected by the CM and LLNL in accordance with the Federal Government procurement process. This laboratory will be responsible for providing timely testing and reporting of results of all laboratory specimens issued to them by the CM and the CQA inspection staff. The purpose of the geotechnical laboratory is to act as a third-party laboratory to test 10% of all soil samples taken for a quality control check. All testing is to be performed in strict compliance with the procedures outlined in Table E-2 of Appendix E.

1.5.3.7 Consultants

Authorities in engineering geology, geotechnical engineering, geology, soil science, chemistry, and other technical disciplines may be called in from external organizations in the event of unusual site conditions or test results.

1.5.3.8 Construction Contractor

The construction contractor will be chosen from a prequalified group of bidders who will be selected by LLNL and the CM. The responsibility of the construction contractor is to construct the final cover system in strict accordance with the design criteria, plans, and specifications, using the necessary construction procedures and techniques. The construction contractor will have the authority to direct and manage his/her employees, equipment, and subcontractors to complete the construction project.

1.5.4 Time Allowed for Commencement of Closure [22 CCR 66265.113(a) and 40 CFR 265.113(a)]

According to 22 CCR 66265.113(a) and 40 CFR265.113(a), closure must commence within 90 days after the treatment of the final volume of hazardous wastes in the HE Open Burn Treatment Facility or within 90 days after the approval of this interim status closure plan by the DTSC, whichever is later. LLNL may request an appropriate extension of the time allowed prior to commencement of closure if the approval date and the 90-day grace period do not coincide with the closure schedule. Construction is scheduled to occur during the period from April 15 to November 15 in order to avoid weather delays and/or deterioration of quality resulting from heavy rainfall and unsuitable site conditions. The schedule is presented in section 1.5.6. Depending on when the closure plan is approved, an extension may be requested for these reasons: (1) October through March is the rainy season in northern California; an extension may be necessary to postpone cap construction until the dry months, April through September; (2) because the earliest recommended planting time for the vegetated cover is the beginning of the rainy season, October, an extension to complete the cap and seed the final cover at the optimum planting time may be required (see section 1.5.5.); (3) construction should be timed to begin early in the dry season to accommodate any delays due to administrative interruptions and the occasional restriction of access to the work areas resulting from Site 300 experimental activities; and (4) adequate time must be available between approval of the Closure Plan and the start of the construction period to complete the contractor selection process in compliance with federal and state procurement requirements.

1.5.5 Time Allowed for Closure [22 CCR 66265.113(b) and 40 CFR 265.113(b)]

The procedures for final closure will be scheduled so that final closure of the pits is accomplished within the prescribed 180 days after commencement of closure activities.

1.5.6 Closure Schedule [22 CCR 66265.112(b)(6) and 40 CFR 265.112(b)(6)]

The proposed closure schedule presented in Figure 1.5-2 provides for closure within the normal local grading season that begins on April 15th and concludes on November 15th. The proposed time period for closure allocated within the attached schedule begins on April 15th and concludes on October 15. This corresponds to 156 days, which lies within the required 180-day closure window. The schedule details the construction and inspection activities and their durations to accomplish closure. At critical times during construction, the CQA activities are scheduled, including the notification to the regulatory agencies.

During the closure period, the project CQA staff will update the schedule monthly and provide copies to LLNL and the regulatory agencies. The final schedule will be provided within the final CQA report as "as built" documentation. The closure of the HE Open Burn Treatment Facility is a partial closure at Site 300. The closure of other hazardous waste units at Site 300 are addressed in separate, unit-specific closure plans. The HE Open Burn Treatment Facility will be closed as a single unit.

1.5.7 Decontamination Procedures [22 CCR 66265.112(b)(4) and 265.114 and 40 CFR 265.112(b)(4) and 265.114]

Construction techniques to be used in the placement of the final cover system have been designed to avoid penetration into the existing fill. In addition, based on extensive soil sampling and analyses, none of the constituents of concern, explosives compounds, metals, or TCE are present in concentrations above levels hazardous to human health (Appendix H). Therefore, no decontamination procedures will be required during the construction phase.

1.5.8 Project Documentation

Documentation will provide a permanent record that the CQA activities are performed and that the construction operations meet or exceed the design criteria given in the final closure plan. A systematic filing and cross-referencing of information will provide quick and easy access in the future. This section outlines the proposed format, content, and frequency of documentation required in conjunction with the closure operation.

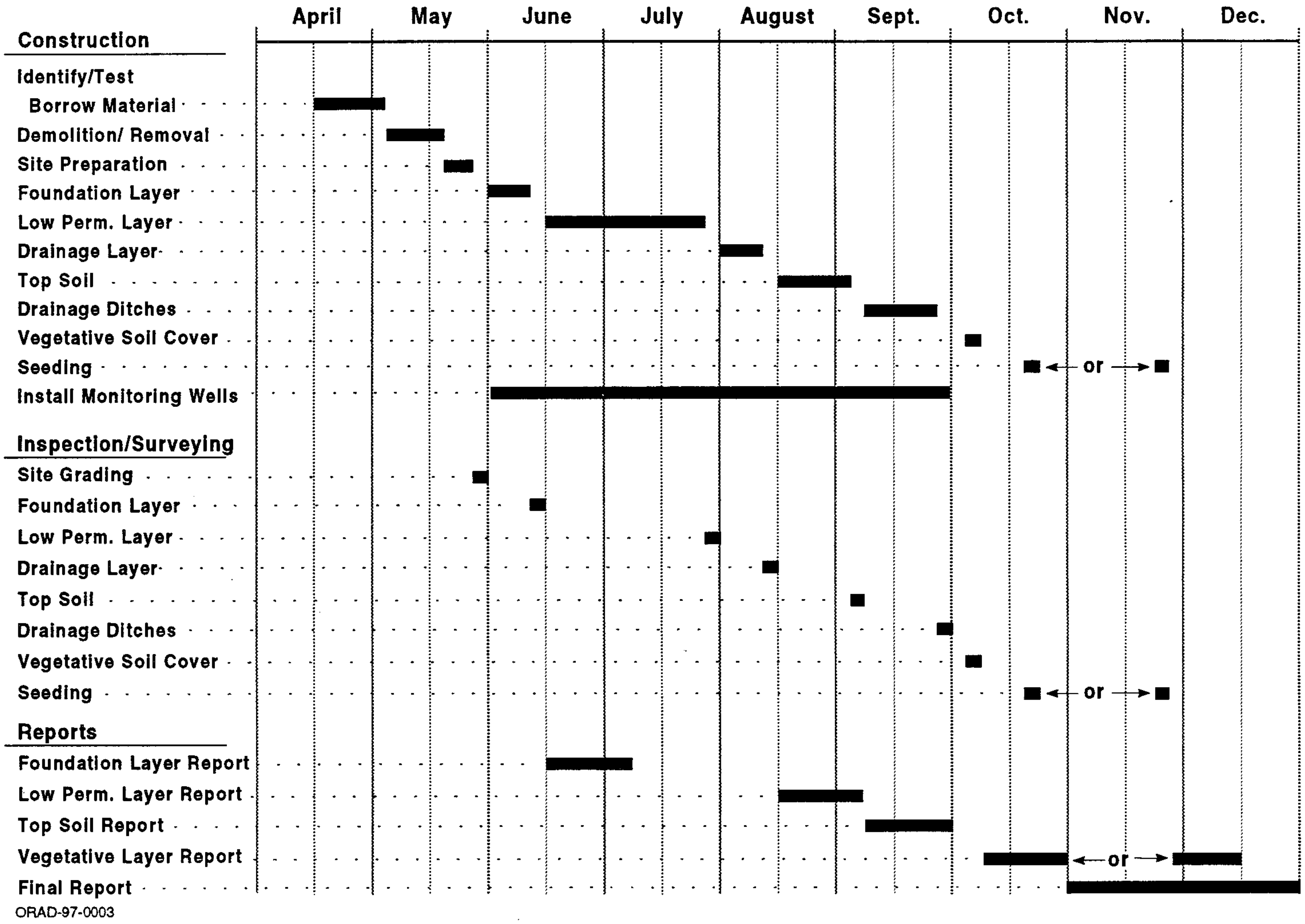


Figure 1.5-2. Proposed closure construction schedule, HE Open Burn Treatment Facility, LLNL Site 300.

Table 1.5-1. Summary of project documentation.

Documentation Item	Prepared By	Frequency of Preparation	Submitted To
Construction Daily Summary Report	CQA Inspectors	Every construction day	CM
Monthly Summary Report	CQA Inspectors	Every construction month	EPA/DTSC/PE/RWQCB
Inspection Data Sheets	CQA Inspectors	Every construction day	CM
Problem Identification and Corrective Measures Report	CM	As needed	Project Design Engineer
Photographic/ Video Documentation	CM & CQA Inspectors	As needed	Submitted with applicable inspection data
Topographic Surveys	Licensed Land Surveyors	Upon completion of each layer of the final cover system	CM
Block Evaluation Reports	CM	Upon completion of each layer of the final cover system	Project Design Engineer
Design Engineer's Acceptance Reports	Project Design Engineer	Upon completion of each layer of the final cover system	EPA/DTSC/PE/RWQCB
Final Report	CM/PE	Upon completion of the closure	EPA/DTSC/RWQCB

Quality assurance documentation for the Construction Manager and Construction Quality Assurance inspectors is described in the Plant Engineering Construction Division Quality Assurance Plan (Plant Engineering, M-078-30.1, Rev. 0). Project documentation, applicable requirements, and responsibilities are summarized in Table 1.5-1.

1.5.8.1 Construction Daily Summary Reports

The CM will complete a summary report on daily construction activities for every working day when construction is performed. The information contained within the daily summary will include the following:

1. A reference number for the sheet.
2. The name and signature of the on-duty CM.
3. The date.
4. The site name.
5. The weather.

6. Construction equipment onsite.
7. The contractor's work force, including subcontractors.
8. Any materials received onsite.
9. Inspections performed, including the inspection sheet cross-reference number.
10. Any problems encountered and the corrective action taken, including the cross-reference number of the problem identification and corrective measures report.
11. The location of samples taken and the direction of travel of compaction equipment will be noted on the Construction Daily Summary Reports. Additionally, these locations and information will be recorded on a master grid map to be presented in the Block Evaluation Report and in the Final Report under the subject heading of "as built" drawings.

A sample "Construction Daily Summary Report" is included in Appendix E.7. A monthly summary report, incorporating the daily summaries for the applicable period, will be filed with the regulatory agencies. This report will be submitted no later than the 15th of the following month.

1.5.8.2 Inspection Data Sheets

Inspection Data Sheets will be prepared for all CQA inspections performed in conjunction with the final closure project. Samples of original field testing data sheets are in Appendix E, "Inspection Data Sheets." The format and content of the Inspection Data Sheets will be in accordance with the guidelines set forth under the subsection of this CQA Plan, entitled "Inspection Methods."

1.5.8.3 Problem Identification and Corrective Measures Report

Reports on any construction quality assurance problems identified during the course of construction activities will be prepared by the on-duty CM. The items to be included within these reports are the following:

1. A reference number for the report.
2. The cross-reference numbers of the applicable Daily Construction Summary Sheet and Photographic Documentation Sheets.
3. The name and signature of the CM.
4. The date.
5. A full description of the problem encountered, including the type and extent, the location, and any other details useful in conveying the nature of the problem.
6. A full description of the corrective actions taken and cross-reference numbers of the applicable inspection sheets.

A sample "Problem Identification and Corrective Measures Report" form is included in Appendix E.7.

1.5.8.4 Photographic Documentation

Photographs will be taken by the CM and the CQA staff as necessary to document the construction, inspection operations, and corrective measures as they progress. The photographs will be mounted on 8 1/2 × 11-in. durable paper stock and bound in chronological order in a permanent protective binder. The mounted photographs will be accompanied by the following information:

1. A cross-reference number for construction inspection sheets.
2. The date.
3. The location.
4. A description of the work or inspection being performed.
5. The purpose of the photograph.
6. The name and signature of the photographer.

Where practical, the photographer will take photographs from known reference points, at the perimeter and within the working area, which will be established by the site surveyors. If deemed appropriate, telephoto or wide-angle lenses will be utilized to establish documentation detail. A sample "Photographic Data" sheet is included in Appendix E.7.

If a CM deems that a video recording will provide a better means of conveying the information to be displayed, the recording will be in VHS format, on high-quality video tape at SP speed (reproducible). It will contain, as a minimum, all of the above outlined information necessary for photographic documentation.

1.5.8.5 Topographic Surveys

Topographic surveys of the hazardous waste facility area will be performed by a licensed land surveyor during construction operations to provide a comparative data base for the thickness of material layers and to assess surface drainage of the affected areas. Field data obtained for these surveys will consist of spot elevations obtained on a 50-ft grid covering the entire areas affected by the grading operations. The accuracy of the elevations obtained will be ±0.1 ft. Surveys will be performed after the completion of initial preparation of the temporary cover, and upon completion of each subsequent material layer of the final cover system.

The results of the topographic surveys will be contained within each applicable Block Evaluation Report and in the Final Report under subject heading of "as built" drawings.

1.5.8.6 Block Evaluation Reports

Upon completion of the grading operations for each layer of the final cover system, a "Block Report" will be prepared by the CM. This report will integrate and summarize all of the inspection and CQA activities performed on the subject material layer during grading operations. Block Evaluation Reports will contain the following information:

1. A complete description of the block evaluated.
2. The time period in which the CQA activities occurred.
3. The design criteria used to establish field controls for CQA activities.
4. A tabulation of the results of testing and inspections performed.
5. A statement of compliance or noncompliance with the design criteria. If there are areas of noncompliance with the original design criteria, statements regarding the reasons for acceptance of work constructed outside of the design criteria will be included.
6. A photographic documentation summary report for the block construction operations and CQA activities.
7. The name and signature of the CM.

All "Block Evaluation Reports" will be submitted for the design engineer's approval of the completed components.

1.5.8.7 Design Engineer's Acceptance Reports

The project design engineer will review the CQA information submitted by the CM, including, but not limited to, Daily Construction Summary Reports, Surveys, Inspection Reports, Problem Identification and Corrective Measures Reports, Photographic/Video documentation, and Block Evaluation Reports.

Upon reviewing this information, the project design engineer will issue periodic Design Engineer's Acceptance Reports upon the completion of construction activities for each of the material layers of the final cover system.

1.5.8.8 Final Report

Upon completion of the project, LLNL will prepare a final report on the closure. This report will integrate into a single document all of the CQA documentation/reports on the project and the Design Engineer's Acceptance Reports. The final report will be prepared by the CM and the PE for the project and submitted to the LLNL Project Design Engineer. Based on this final report, LLNL will submit to the DTSC a certification that the HE Open Burn Treatment Facility has been closed in accordance with the specifications of the approved closure plan (see section 1.1.4.1).

1.5.8.9 Storage of Documents

Provisions will be made to store at Site 300 all CQA inspection reports, photographic/video logs, and other pertinent documents for the required post-closure care period.

A custodian shall be appointed by LLNL to be responsible for care of the documents. If the appointed custodian leaves the employ of LLNL, provisions shall be made for a replacement.

1.6 Details of Final Cover

1.6.1 Cap Construction and Design [22 CCR 66265.310(a) and 40 CFR 265.310(a)]

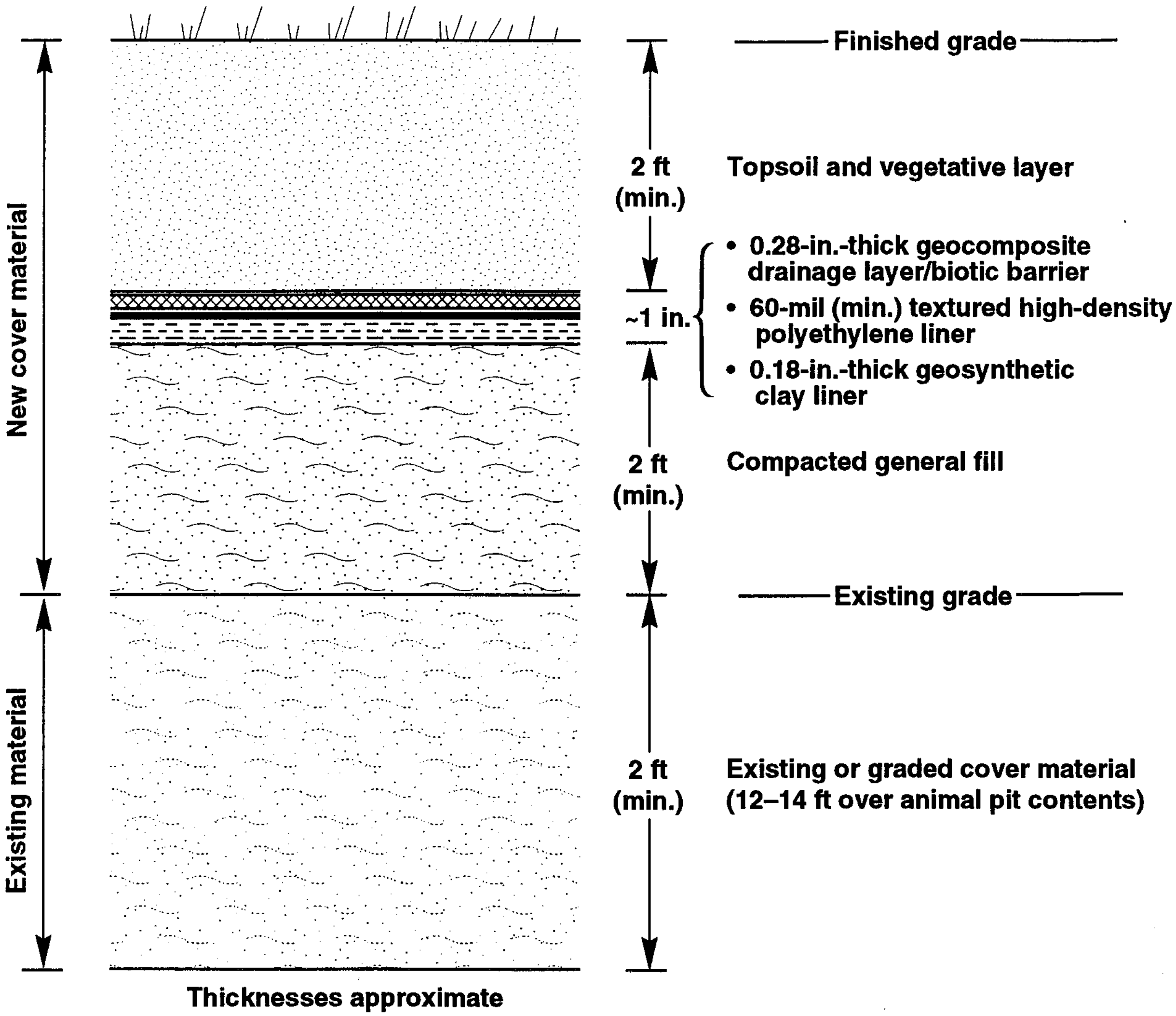
The construction of the cover for the burn facility area cap (Figs. 1.6-1 and 1.6-2) is outlined below. For additional details, refer to Appendices D and E.

1. After the final waste treatment at the HE Open Burn Treatment Facility, the first step of closure will be to remove the metal burn pad, Iron Horse, burn cage, and underground diesel tank (Fig. 1.2-4). The concrete and asphalt berm will be removed from the site and disposed of (Construction Drawing D-1 in Appendix D.5). Onsite soil sources will be identified and tested. Documentation of offsite soil sources will be obtained and verified.

2. Following proof-rolling, a minimum thickness of 1 ft of soil derived from the designated borrow area will be compacted to form the foundation layer for the low-permeability barrier. Each pit will be filled with 4 to 5 ft of borrow material. The material will be applied in layers approximately 1 ft thick and compacted before the next layer is added. The layer will be inspected prior to the installation of the low-permeability layer to assess that the surface is free of large protrusions as described in Appendices D and E. Final elevations of the foundation layer are presented in Construction Drawing D-2 (Appendix D.5).

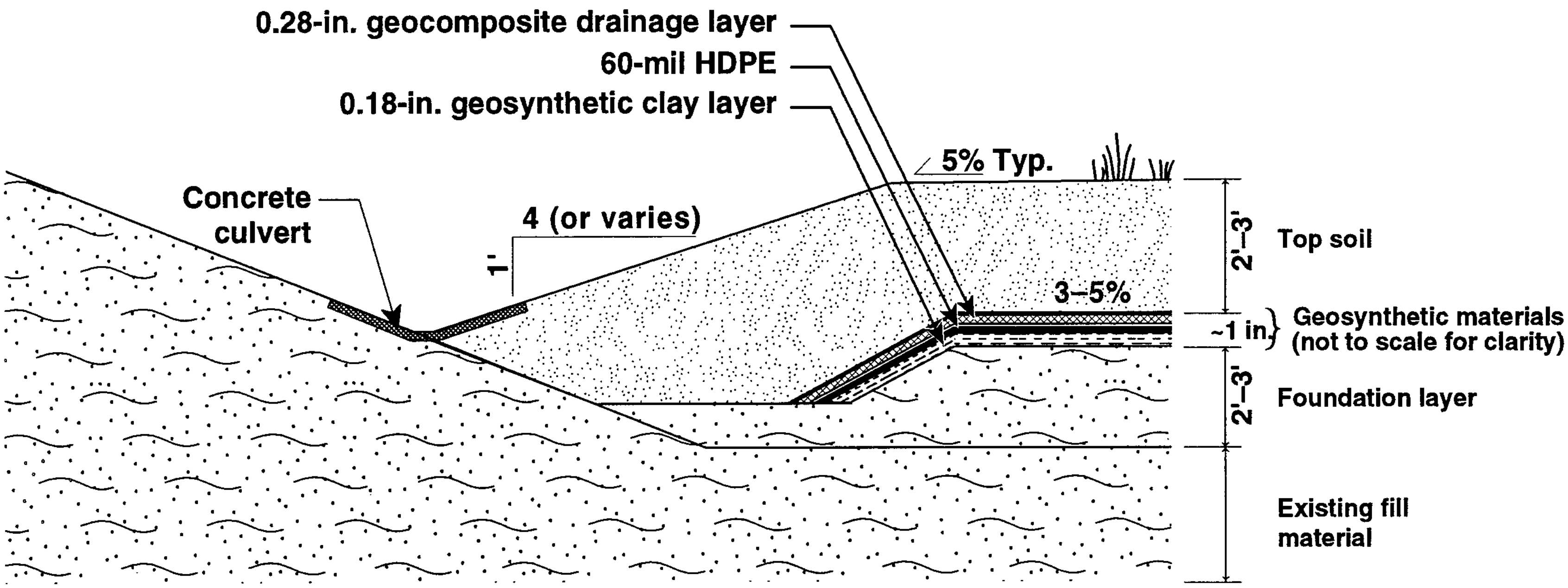
3. A 0.18-in.-thick geosynthetic layer impregnated with bentonite clay will be placed on top of the foundation layer. It will possess a permeability of 1×10^{-7} cm/s or less. The CM will be present to inspect the installation of the low-permeability layer as it is placed. The independent professional engineer will also verify that the proper procedures are followed (Construction Drawing D-3 in Appendix D.5).

4. A 60-mil-thick HDPE geomembrane will be placed on top of the geosynthetic layer. A 0.28-in.-thick geosynthetic drainage layer will be placed on top of the HDPE membrane layer. The CM will be present to inspect delivery and installation of the geosynthetic drainage layer and to supervise testing by the QA/QC personnel. The independent PE will also verify that proper procedures are followed and act as liaison with the contract installers (Construction Drawing D-3 in Appendix D.5).



ORAD-97-0004

Figure 1.6-1. Typical cap section—HE Open Burn Treatment Facility closure, LLNL, Site 300.



Scale: 1"= 4'

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Figure 1.6-2. Typical edge section along upslope—HE Open Burn Treatment Facility, LLNL Site 300.

5. The geosynthetic drainage layer will be covered with at least 2 ft of local topsoil taken from the designated borrow areas. This layer will be planted prior to onset of the rainy season with a vegetative cover to prevent wind and water erosion. The geosynthetic drainage layer and HDPE membrane layer will protect the geosynthetic layer from roots penetrating the topsoil. Rooting depths of the selected cover vegetation are less than 1 ft (Construction Drawing D-4 in Appendix D.5).
6. The topsoil layer will be graded prior to seeding for installation of a drainage channel to be constructed of concrete (Construction Drawing D-5 in Appendix D.5).

1.6.2 Lateral Extent of Cap [22 CCR 66265.310(a) and 40 CFR 265.310(a)]

The cap will extend laterally at least 25 ft beyond the perimeter of the existing burn units. The capped area will be slightly larger than the existing fenced area (about 17,000 ft^2). The near surface sample results for VOCs and explosives compounds are presented in Figures 1.6-3 and 1.6-4. Based on comparison with the DTLs discussed in section 1.3.3.2, the area in need of capping is limited to the area within Pit 2. Extending the cap to cover the other units with a 25-ft buffer area provides the cap with an additional margin of safety. No additional soil samples are anticipated within the scope of closure activities for the HE Open Burn Treatment Facility. If additional soil samples are needed, the sampling will follow the protocols described in section 1.3.3.2.

1.6.3 Minimization of Liquid Migration [22 CCR 66265.310(a)(1) and 40 CFR 265.310(a)(1)]

The main design element of the final landfill cover is the low-permeability layer consisting of a geosynthetic clay-impregnated layer overlain by an HDPE geomembrane. For most Resource Conservation and Recovery Act (RCRA) facilities, the low-permeability barrier is considered the critical component for the long-term stability of the wastes. In addition, leaching will be minimal because of the low mobility of the explosives compounds and metals in the subsurface, their low concentrations, the high climatic evapotranspiration rate, and the absence of free liquids in the pits. A 0.18-in.-thick, low-permeability, 10^{-7}-cm/s geosynthetic clay barrier and a 60-mil-thick, HDPE geomembrane are proposed to prevent surface water from infiltrating to the subsurface. The overlying topsoil is designed to protect the low-permeability clay layer and the 0.28-in.-thick geosynthetic drainage layer from direct weather and climatic effects. The low-permeability layer will be primarily responsible for preventing rain water from percolating into the subsurface.

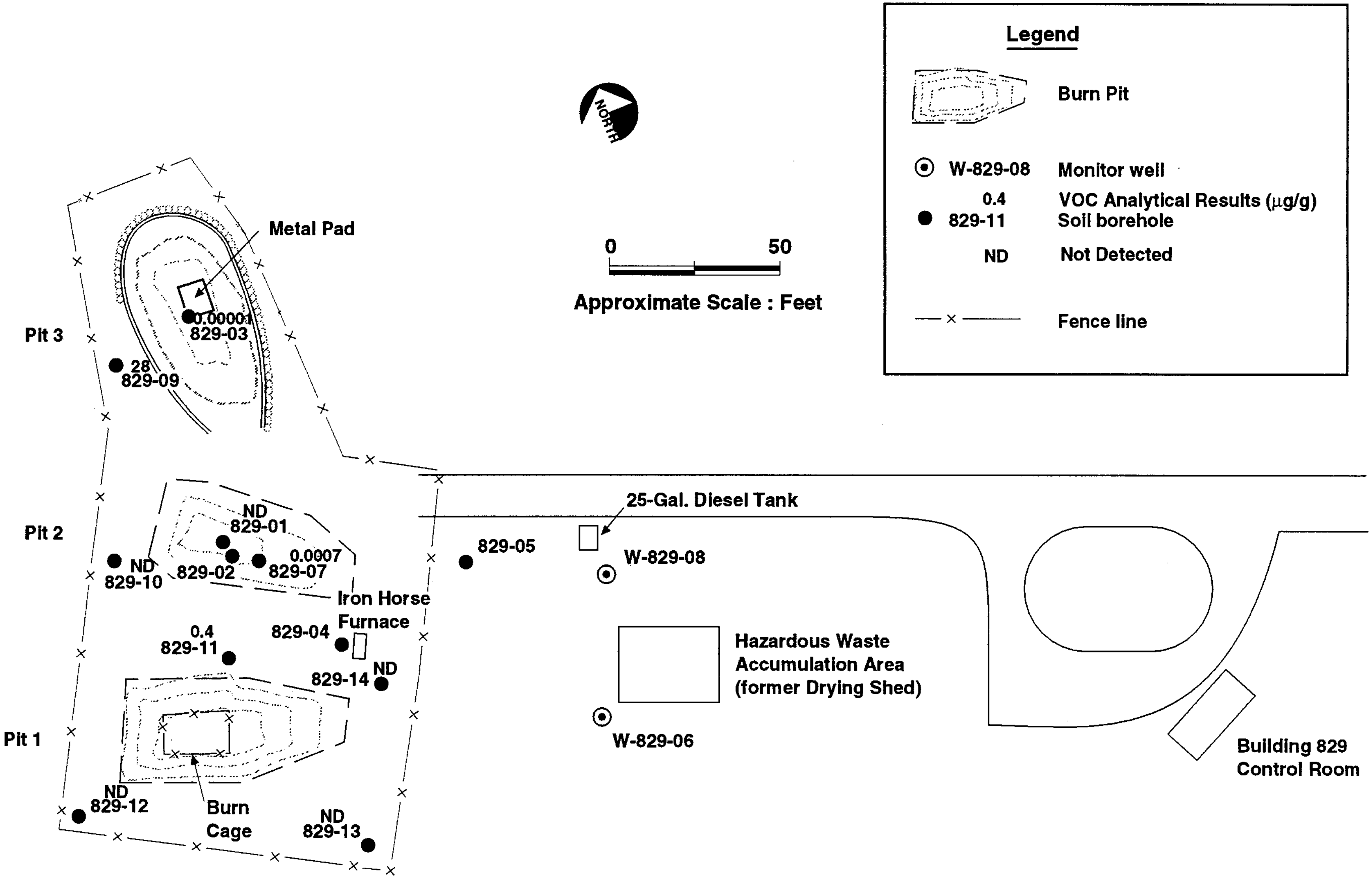

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Figure 1.6-3. Building 829 near-surface soil sample VOC concentrations.

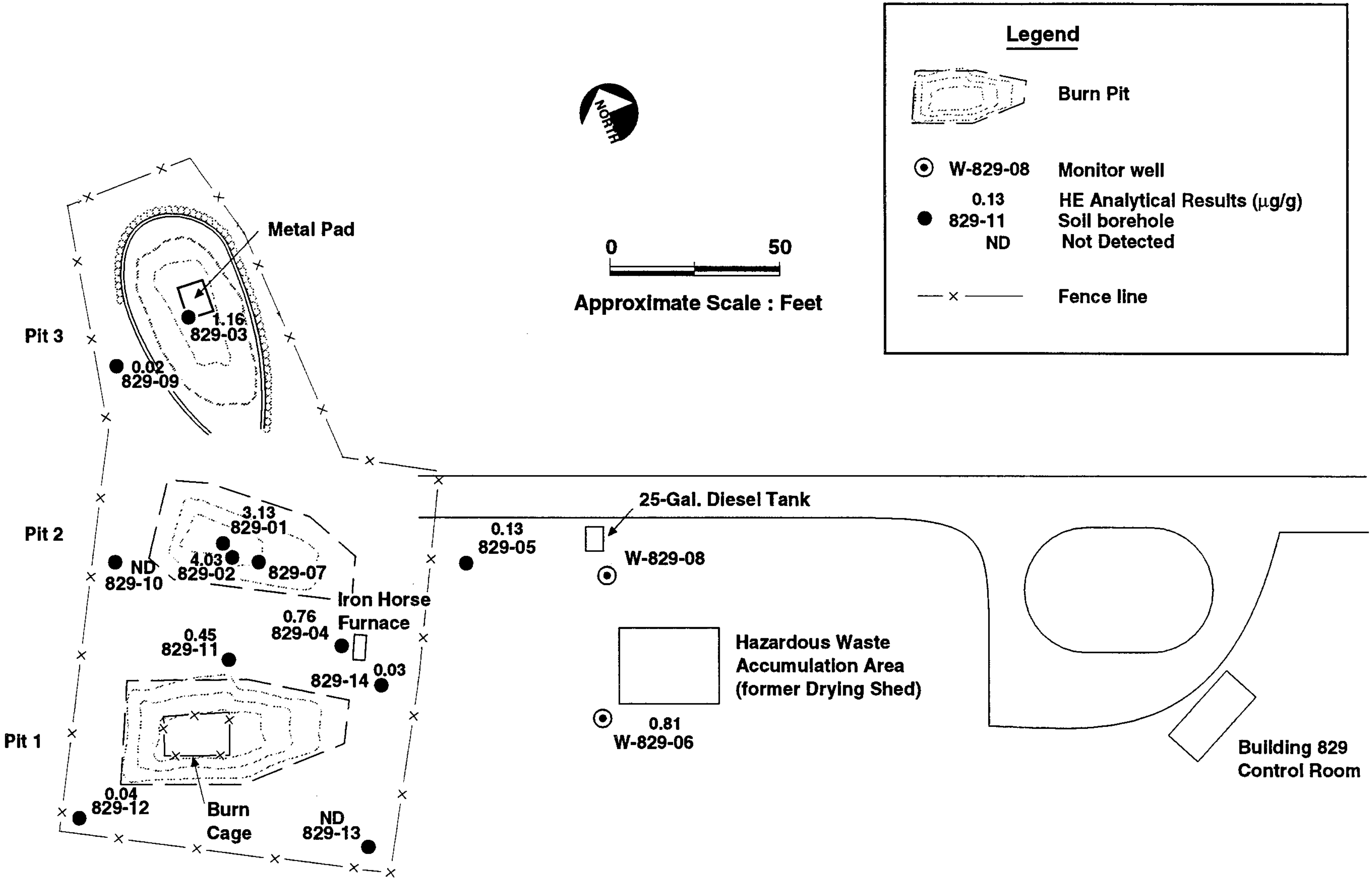

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Figure 1.6-4. Building 829 near-surface soil sample total HE concentrations (HMX+RDX+TNT).

Due to the location of the HE Open Burn Treatment Facility on a ridge at high elevation away from the predominant ground squirrel habitat, potential biotic intrusion through the geosynthetic and HDPE layers to the subsurface is limited to root penetration. A grass with a shallow root system (<1 ft) will be selected as the final vegetative cover. Periodic inspection will be conducted to assess the cover's condition, and any weeds would be removed at that time. Therefore, LLNL has concluded that a biotic layer will not be necessary for the final cover. Regardless, it is believed that the upper HDPE geomembrane will prevent penetration of any deep roots that could reach it.

1.6.4 Accommodation of Settlement and Subsidence [22 CCR 66265.310(a)(4) and 40 CFR 265.310(a)(4)]

Results of the analysis of predicted settlement of the HE Open Burn Treatment Facility closure cap indicate that the maximum amount of settlement would occur in the southwest portion of the facility near Pit 1 where the depth of fill is greatest. It is estimated that approximately 1 in. of total static settlement will occur in this area as a result of consolidation of the existing fill and cap materials (Rogers/Pacific, 1990). The analysis is based on the results of an exploratory drilling and lab testing program described in Appendix G.

At the south perimeter of the site, basically ***no*** settlement is expected to occur. The perimeter is about 20 ft from the area where 1 in. of settlement is expected. This equates to a differential settlement of 1/240 and equates to a low level of settlement-induced strain in the cover system. In addition, subsidence of the final cover is expected to be minimal because no waste has been buried at the site, which will be proof-rolled before applying the foundation layer (Rogers/Pacific, 1990).

Minor overall settlement may occur over time due to the addition of the final cap; minor subsidence may occur in localized areas because of uneven compaction. If settlement or subsidence conditions interfere with free drainage, they will be corrected as found.

1.6.5 Runoff and Other Controls [22 CCR 66265.112(b)(5) and 265.310(a)(2) and 40 CFR 265.112(b)(5) and 265.310(a)(3)]

The main design features of the final cap are: (1) the low-permeability layers to prevent seepage into the original fill material and (2) surface runoff drainage to minimize the amount of runoff that could infiltrate to and through the low-permeability layer. Currently, Pit 3 is rimmed by concrete and asphalt, which prevent surface runoff from accumulating in the pit. Runoff from the adjacent hillside accumulates on the graded level northeast and east of Pit 3 and either infiltrates or evaporates.

Surface runoff from the burn sites and the area up-slope drains to the south and west, following the natural drainage before reaching a tributary to the Corral Hollow Creek. Most surface water evaporates or infiltrates before reaching Corral Hollow Creek about 1 mile to the south. However, during large rainfall events, runoff in nearby ravines reaches the creek. For flow from the HE Open Burn Treatment Facility site to drain off Site 300, surface water would travel about 1.5 miles before reaching the southern Site 300 boundary. A complete description of the drainage system, the engineering calculations, and the design specifications are presented in Appendix E.

The HE Open Burn Treatment Facility burn pits were constructed without liners or underdrain piping systems to collect leachate. This plan includes the development of diversion ditches and adequate grading of the final cover to minimize infiltration and divert rainfall and surface-water flows away from the closed burn pits. Because no waste material is buried at the site and infiltration will be minimal, no significant volume of leachate will be generated that requires leachate containment systems. The low-permeability layer will minimize infiltration to the foundation layer and subsurface soils. The design features, combined with the siting of the HE Open Burn Treatment Facility site in a high, relatively dry location, minimize the potential of producing leachate from the burn pits and, therefore, no leachate containment system will be necessary. Also, because no wastes are buried at the site, gas generation does not occur and is not anticipated; therefore, neither leachate controls nor gas controls are planned for the final cap cover.

1.6.6 Maintenance of Final Cover [22 CCR 66265.310(a)(2) and 40 CFR 265.310(a)(2)]

The final cover has been designed to function with minimal maintenance, by incorporating these design features: preparation of a foundation layer to minimize local subsidence, a slope on the cap to minimize percolation and erosion, and a vegetated cover to reduce erosional effects of wind and surface water. The actual maintenance required for the final cover is discussed in section 2.3.1.

The local soils were not tested for engineering properties prior to construction of the existing facility. However, geotechnical soil sampling was conducted during design of the closure. Laboratory tests indicate that these local soils are erosion-resistant and moderately expansive (Appendix F).

A 50-50 blend of Red Brome (*Bromus rubens L.*) and "Zorro" Annual Fescue (*Vulpia myuros L.*) has been selected as the optimum plant species for the particular climate and soil type at Site 300. This cover vegetation is based on the recommendations of the U.S. Department of Agriculture, Soil Conservation Service (SCS) in Stockton, California. These annual grasses have shallow roots (generally 4 to 7 in.), require low maintenance, are drought-resistant, and will provide good erosion control. The Zorro is especially well suited to dry areas with disturbed soils. Seeding will take place during the recommended fall planting season, October 1 to November 15. Seed will be applied at 24 lb per acre with fertilizer (16-20-0) at 500 lb per acre as specified by SCS. Information about both grasses is provided in Appendix F.

1.6.7 Permeability Standard [22 CCR 66265.310(a)(5) and 40 CFR 265.310(a)(5)]

The final cover will include a geosynthetic clay layer at least 0.18 in. thick with a permeability of less than 1×10^{-7} cm/s. Local soils that were used to construct the burn site have permeability of approximately 1×10^{-5} cm/s (Raber, 1983). The presence of shrinkage cracks, induced during dry periods, may increase secondary permeability in the clay-rich local topsoil during the beginning of wet periods. The pits are unlined trenches, and, as stated, the cap will have a permeability that is less than that of the facility subsoils.

1.6.8 Freeze and Thaw Effects

As discussed in section 1.2.1, the climate of Site 300 is general characterized by mild, rainy winters and hot, dry summers. The thermal expansion and contraction will have little effect on the clay cap. The effect of thermal expansion will be much less than the shrinkage cracking induced during dry periods.

Chapter 2
Post-Closure Plan

Chapter 2. Post-Closure Plan

2.1 Introduction

2.1.1 Post-Closure Use of the Property [22 CCR 66265.117(d) and 40 CFR 265.117(c)]

Research operations for the U.S. Department of Energy (DOE) at Site 300 are expected to continue indefinitely. No other plans for the Site 300 property exist or are anticipated. The HE Open Burn Treatment Facility is located at a highly secure site and will be used as open space. Post-closure use of the area will not be allowed to disturb the integrity of the final cover or any of the components of the monitoring system unless approved by the DTSC.

2.1.2 Post-Closure Contact [22 CCR 66265.118(c)(3) and 40 CFR 265.118(c)(3)]

Because Site 300 will continue as an active facility indefinitely and long after the HE Open Burn Treatment Facility is closed, a copy of the approved post-closure plan and all revisions will be kept at Site 300 in the Administration Building (B871). The following person and alternate can be contacted about the closed facility at Site 300 during the post-closure care period:

C. Susi Jackson, Division Leader
Operations and Regulatory Affairs Division
Environmental Protection Department
Lawrence Livermore National Laboratory
P.O. Box 808, L-633
Livermore, California 94551
Telephone: (510) 423-6577

Milt Grissom, Site 300 Manager
Lawrence Livermore National Laboratory
P.O. Box 808, L-871
Livermore, California 94551
Telephone: (510) 423-1396

2.1.3 Amending the Post-Closure Plan [22 CCR 66265.118(d) and (g) and 40 CFR 265.118(d) and (g)]

LLNL will amend the post-closure plan whenever changes in the operating plans occur during the post-closure care period. Requests for modifications to the post-closure plan will be made within 60 days after any unforeseen changes occur or at least 60 days prior to any proposed changes in operations or events that affect this plan.

2.1.4 Length of the Post-Closure Care Period [22 CCR 66265.117(b)(1) and 40 CFR 265.117(a)(1) and 265.118(g)]

Post-closure care of the closed facility and ground water monitoring will continue for the required 30 years after the closure completion date unless a petition for reduction or termination of post-closure care is requested and approved by the DTSC after several years of monitoring. Maintenance of the closed burn pits during the post-closure period reflects the prime consideration to protect human health and the environment and to prevent any infiltration of rain water that may cause the low concentrations of explosives compounds and VOCs in near-surface soils to migrate to ground water.

2.1.5 Cost Estimates [22 CCR 66265.144 and 40 CFR 265.144] and Financial Assurance [22 CCR 66265.145 and 40 CFR 265.145]

Because Site 300 is a U.S. Government facility, it is exempt from Subpart H under 22 CCR 66265.140(c) and 40 CFR Part 265.140(c); cost estimates and financial assurance documents for post-closure care are not included.

LLNL is a federal research facility owned by the DOE and operated under contract by the University of California. LLNL Site 300 is a portion of the LLNL facility. Site 300 is currently on the CERCLA National Priority List. Ground water and soil clean-up activities will be administered under the Federal Facilities Agreement. DOE is an agency of the federal government funded by the United States Congress. The United States Congress authorizes funds to meet the mission requirements as well as the financial obligations of the laboratory.

2.1.6 Notice to Local Zoning Authority [22 CCR 66265.119(a) and 40 CFR 265.119(a)]

Within 60 days following the certification of closure of the facility, LLNL will submit to the local zoning authority or the authority with jurisdiction over local land use, and to the DTSC, a record of the type, location, and quantity of hazardous wastes treated in the HE Open Burn Treatment Facility.

2.1.7 Notice to the Deed [22 CCR 66265.119(b)(1) and 40 CFR 265.119(b)(1)]

Within 60 days after certification of closure of the facility, LLNL will record a notation on the deed to the facility property (or on some other instrument that is normally examined during a title search), which will notify in perpetuity any potential purchaser that the property has been used to manage and treat hazardous waste and that the use of this land is restricted under 22 CCR Chapter 15, Article 7 and 40 CFR Part 265, Subpart G. Furthermore, the notice to the deed will include information that the survey plat and a record of type, location, and quantity of wastes have been filed with the local zoning or land use authority and with the DTSC as required by 22 CCR 66265.116 and 66265.119(a) and 40 CFR 265.116 and 265.119(a).

2.1.8 Certification of the Notice [22 CCR 66265.119(b)(2) and 40 CFR 265.119(b)(2)]

LLNL will submit a certification signed by the owner (DOE) and the operator (University of California) that the notice to the deed described above has been recorded; a copy of this record will be sent to the DTSC.

2.2 Security [22 CCR 66265.117(c) and 40 CFR 265.117(b)]

During the post-closure care period, 24-hr surveillance will be maintained at Site 300 for 7 days a week, through a combination of the following:

1. 24-hr security patrol of the facility.
2. Controlled access to the facility, which is open only to authorized visitors.
3. Television monitoring by security personnel of portions of Site 300.

All visitors must report to the main entry gate on Corral Hollow Road, fill out personal information sheets, and receive badges before being accompanied to any of the Site 300 buildings or facilities by an authorized LLNL employee. Badges must be presented to protective force officers, who are stationed at the main entry gate to the facility, as well as at designated locations within Site 300 where there are police posts for access control.

The entire perimeter of Site 300 is enclosed by a 4-ft-high, barbed-wire fence. Signs are placed around the perimeter of Site 300 on the barbed-wire fence and state:

KEEP OUT
TRESPASSING OR LOITERING
FORBIDDEN BY LAW
EXPLOSIVES TEST AREA
UNIVERSITY OF CALIFORNIA RADIATION LABORATORY
UNITED STATES GOVERNMENT PROPERTY
NO TRESPASSING BY ORDER
OF THE UNITED STATES
DEPARTMENT OF ENERGY

In addition, three warning signs are posted at the HE Open Burn Treatment Facility. The signs, which are posted at the landfill entrances and at points where trespassers might gain access, are written in English and Spanish:

DANGER
HAZARDOUS WASTE FACILITY
KEEP OUT
PELIGRO
ZONA DE RESIDUOUS PELIGROSOS
NO ENTRE

These signs are visible from a distance of 25 ft.

2.3 Inspection and Maintenance

Detailed visual inspections will be made quarterly and after each major storm for the final cover, drainage and diversion ditches, ground water monitoring system, signs, etc., as detailed in the inspection checklist provided on Table 2.3-1. Any deficiencies noted, such as erosion of landfill cover, fissures or low spots in the top cover, burrowing by animals, and bare areas needing reseeding, will be corrected. Those individuals responsible for conducting the inspections at the facility will have copies of the schedule and the inspection checklist.

Table 2.3-1. HE Open Burn Treatment Facility post-closure inspection checklist.

Location: ____________________ Inspector's name: ______________________________

Date : ____________________ Inspector signature: ______________________________

Time: ____________________

Condition of the facility	Condition as described?	If correction needed: Describe condition and needed repairs.	Corrections completed?	
DESCRIPTION	Y/N	INSPECTOR'S COMMENTS	Y/N	DATE
1. The cap is in good repair; no settlement or gullying.				
2. Run-on is diverted away from the HE Open Burn Treatment Facility.				
3. Erosion controls are present and in good condition (i.e., grading vegetation, and clear diversion channels).				
4. Permanent, surveyed Benchmarks are present and maintained.				
5. A ground water monitoring network is in good working order.				
6. Warning sign in place.				
7. Emergency Coordinator name and phone number posted.				
8. Telephone in working order.				
9. Access available to emergency vehicles.				
10. Copy of Post-Closure Plan on file at Site 300.				
11. List any other observations:				

As practiced during the active life of the HE Open Burn Treatment Facility, if inspections reveal the need for maintenance, repairs are scheduled. Maintenance personnel who perform the remedial action, or their supervisor, record the nature of the repairs, date, and sign the inspection checklist. The checklists are reviewed to ensure the inspection and remedial-action schedules are being followed. All completed forms are accumulated and retained for 3 years by the Environmental Safety and Health Team 1.

2.3.1 Inspection and Maintenance of the Final Cover [22 CCR 66265.310(b)(2) and 40 CFR 265.118(c)(2)(A) and 265.310(b)(1) and 265.118(c)(2)(i)]

Throughout the post-closure period, the structural integrity and effectiveness of all containment structures will be maintained. The final cover will be adjusted as necessary to correct the effects of settlement and erosion. Slight damage to the final cover by settlement or erosion will be repaired by adding more topsoil and reseeding the new area so that the cap is returned to specified grade and vegetative cover. More severe damage, such as gullying or subsidence that exposes layers beneath the final cover layer, will be repaired using the same procedures and material in the same thicknesses as specified in the approved cover design. It is possible that some vegetative biointrusion could occur but will not penetrate beyond the topsoil layer due to the presence of the upper 0.28-in.-thick HDPE geomembrane. Appropriate measures will be taken to eradicate burrowing animals and repair the final cover. Large plants that could penetrate the HDPE geomembrane (such as trees or bushes) will be removed from the cap before any damage can occur. Any bare spots on the cap will be fertilized and reseeded annually with the Red Brome/Zorro mix.

2.3.2 Inspection and Maintenance of the Ground Water Monitoring System [22 CCR 66265.310(b)(3) and 40 CFR 265.118(c)(2)(B) and 265.310(b)(2) and 265.118(c)(2)(ii)]

To maintain the integrity of the ground water monitoring system, the monitoring wells will be examined and maintained at least quarterly. A logbook will be kept at each installation to document activities performed and observations made each time the monitoring well is used or examined. During routine sampling of the monitoring wells (section 2.4.2), any changes in turbidity of sampled ground water or well yield, anomalous depth-to-water measurements, or any other unusual observations will be documented. If a well exhibits significantly increased turbidity or reduced yield for no known reason, it will be redeveloped using a surge block and bailer or pump to remove fine material. A downhole camera may be used when encrustation of the screen or casing failure is likely. In situations where such problems are confirmed and no less extreme remedy is deemed sufficient, the well will be destroyed. This will be accomplished by removing the casing and reaming out the annular fill material. The resulting borehole will be pressure-backfilled with cement grout to the ground surface to prevent any recharge through the well bore. A new monitoring well will be installed immediately at an equivalent geohydrologic position in the flow system. The borehole will be drilled and the well completed using standard LLNL procedures.

2.3.3 Inspection and Maintenance of the Runoff and Drainage System [22 CCR 66265.310(b)(4) and 40 CFR 265.310(b)(3)]

The cap and the drainage ditches will be inspected quarterly and after each major storm for erosion and accumulated debris. Repairs will be made with similar materials used in the original construction as specified in the approved closure plan. Drainage ditches will be cleared of blockage and regraded as necessary.

2.3.4 Inspection and Maintenance of the Benchmarks [22 CCR 66265.310(b)(5) and 40 CFR 265.310(b)(4)]

Benchmarks placed at Site 300 are surveyed using Mt. Diablo, a U.S. Geological Survey marker located near the West Observation Post (the Elk Monument), and a third benchmark located approximately 5 miles southwest of the Elk Monument. Benchmarks at the site are primarily 3-in.-diam, stainless steel discs set in concrete, although there are a few brass discs set in concrete and others consisting of railroad spikes driven into Corral Hollow Road. All of the Site 300 benchmarks were resurveyed in 1984 to within 0.01 ft. Benchmarks are inspected primarily during usage; if the survey crew finds a benchmark shifted out of position during the course of any job, they will resurvey in its position and reestablish the benchmark. Benchmarks around the HE Open Burn Treatment Facility will be inspected at least quarterly.

2.4 Ground Water Monitoring

2.4.1 Applicability of Ground Water Monitoring Requirements [40 CFR 265.90(c) and 22 CCR 66265.90]

The HE Open Burn Treatment Facility is not a landfill, and ash from the treatment of explosives waste and explosives-contaminated wastes was always removed to a final disposal location; therefore, only residual amounts of explosives contamination potentially remain in subsurface soil and rocks. Because of the low potential for migration of hazardous materials to the regional water-bearing zone and thus to water-supply wells, and the low potential for migration of these materials to surface water, we propose that a ground water monitoring system as outlined in 40 CFR 265.90(c) is not necessary for post-closure monitoring of the HE Open Burn Treatment Facility. The required demonstration and certification is in Appendix J of this report. However, similar exemptions for ground water monitoring do not exist under the California Code of Regulations (22 CCR 66265.90, Applicability). We will therefore monitor wells for the Open Burn Treatment Facility for a comprehensive suite of analytes to meet the requirements of 22 CCR 66265.92.

2.4.2 Required Programs and the Water Quality Sampling and Analysis Plan [22 CCR 66265.91]

LLNL will institute a detection monitoring program in accordance with the requirements of 22 CCR 66265.98. Should significant physical evidence of release or statistically significant evidence of release occur during the post closure monitoring period, LLNL will institute an evaluation monitoring program in accordance with 22 CCR 66265.99.

2.4.3 Water Quality Protection Standard [22 CCR 66265.92]

The following sections establish the "Water Quality Sampling and Analysis Plan" for the HE Open Burn Treatment Facility area. Included are constituents of concern (COCs) (22 CCR 66265.93), concentration limits (22 CCR 66265.94), the point of compliance, and all monitoring points (22 CCR 66265.95).

2.4.3.1 Constituents of Concern [22 CCR 66265.93]

Constituents of concern are defined as any waste constituents, reaction products, or hazardous constituents that are reasonably expected to be in or derived from waste contained in a waste management unit.

Based on historical activities, all of the burn pits basically received the same types of explosives waste containing the explosives compounds: hexahydro-1,3,5-trinitro-1,3,5-triazine or cyclo-1,3,5-trimethylene-2,4,6-trinitramine (RDX), octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraocine or cyclo-tetramethylene-tetranitramine (HMX), 2-methyl-1,3,5-trinitrobenzene or trinitrotoluene (TNT), and triamino trinitrobenzene (TATB); however, wastes were received in different forms. These forms are (1) explosives-contaminated solid debris (paper, cardboard, wood, etc.); (2) explosives-contaminated wastewater; (3) fine explosives particulate collected in process clarifiers; and (4) bulk explosives (pieces, parts, powders, etc.). Some explosives compounds contain lead-azides and barium nitrate.

Waste ash analyses for metals from the HE Open Burn Treatment Facility using the Waste Extraction Test (WET; 22 CCR 66700) resulted in the detection of antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, selenium, silver, vanadium, and zinc. However, beryllium and silver concentrations were quite low. Waste ash was also found to contain 1,1,1-trichloroethane (4–1000 µg/kg), tetrachloroethene (23–780 µg/kg), toluene (3–130 µg/kg), benzene (40 µg/kg), and ethylbenzene (30 µg/kg). These data are presented in Appendix A, Waste Analysis.

In addition to the waste analyses and records of waste treated at the facility, LLNL examined the analytical results of ground water and soil boring samples for additional COCs. For naturally occuring compounds, i.e. metals, LLNL compared the results of analytical testing to background concentrations developed for Site 300 soils and ground water. Those compounds that were detected but were below the established background concentrations were omitted from the discussion and are not proposed as COC, unless included in the waste analyses or waste treatment records.

Results from soil borings (soil and rock) indicated the detection of explosive compounds (HMX and RDX), and organic compounds (trichloroethene, 1,2-dichloroethane, total 1,2-dichloroethene, Freon 113, trichlorofluoromethane, and chloroform). Since metals are naturally occuring compounds within soil, the values detected were compared to background concentrations developed for Site 300. This comparison indicates that the following detected metals exceed the background concentrations and therefore may be a result of activities at 829: antimony, beryllium, cadmium, chromium, copper, lead, and zinc. Data are presented in Tables C1-3 of Appendix C, SWRI Soil and Ground Water Monitoring Data and Table H-1 of Appendix H.

Ground water monitoring data presented in Appendix H indicate the presence of organic compounds (trichloroethene, 1,1,1-trichloroethane, 1,1- dichloroethene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, bis(2-ethylhexyl)phthalate, benzene, ethlybenzene, Freon-113, carbon disulfide, toluene, phenols, dichlorodifluoromethane, and total xylene. Radiological activities for gross alpha, gross beta, and uranium appear to exceed the Site 300 background concentrations. However, the isotopic ratios, as derived from mass spectrometric analyses, indicate that the uranium is natural and therefore it is not proposed as a COC. The gross alpha and gross beta activities are likely to be related to the high uranium activities. Metals detected in the ground water samples that exceed the background concentrations are manganese, barium, beryllium, cadmium, chromium, cobalt, lead, nickel, selenium, vanadium, and mercury. Of these, the only metal detected in regional aquifer ground water in excess of expected background concentration was manganese. The explosive compounds HMX, RDX, TNT, and TATB have not been detected in ground water samples. TATB is not anticipated to ever reach ground water due to its low aqueous solubility and is therefore not proposed as a COC.

Table H-1 in Appendix H presents the historic ground water analytical data for wells W-827-05, W-829-06, W-829-08 and W-829-15 and soil core analytical results. Additional soil core sample results are presented in Appendix C.

Based on the previous discussion and LLNL records documenting constituents used in the HE Open Burn Treatment operations and detected in analyses of waste ash, LLNL specifies the following COCs for which the water quality protection standard of 22 CCR 66265.92 applies (Table 2.4-1).

In October 1994, the existing 30-gal diesel fuel tank system (UST-829-D1U1), comprised of a 30-gal, low, carbon steel drum and approximately 15 ft of piping, was removed and replaced with a new 25-gal aboveground double-walled tank system (AST-829-D1A1). Soil samples from the excavated ground surface 11 ft below grade contained up to 1600 mg/kg TPH-D and 0.076 mg/kg xylene. In December 1994, the tank area was excavated to 17 ft below ground surface. Results indicated a TPH-D of 990 mg/kg. The presence of this constituent infers that another tank may have pre-dated the 30-gal tank, which was installed in 1983.Additional sampling and analysis was conducted at the 17-ft excavation and ranged from 58.0 mg/kg TPH-D to 930 mg/kg TPH-D. Based upon the visual inspection of the tank and its physical integrity, analytical results of the soil samples collected from the excavation, successful completion of the sampling plan outlined in the May 1994 Closure Plan for the UST-829-D1U1, and a local depth to ground water of over 100 ft bgs, the San Joaquin County Public Health Services Environmental Health Division issued a "no further action" letter to LLNL on February 24, 1995. The excavation was filled and restored to grade.

Table 2.4-1. LLNL specified constituents of concern.

Explosive Compounds	
HMX	TNT
RDX	
Metals	
antimony	manganese
arsenic	molybdenum
barium	mercury
beryllium	nickel
cadmium	selenium
chromium	silver
cobalt	vanadium
copper	zinc
lead	
Organic Compounds	
1,1,1-trichloroethane	1,1- dichloroethene
tetrachloroethene	total 1,2-dichloroethene*
toluene	bis(2-ethylhexyl)phthalate
benzene	Freon-113
ethylbenzene	carbon disulfide
trichloroethene	dichlorodifluoromethane (Freon 12)
1,2-dichloroethane	phenols
chloroform	trichlorofluoromethane (Freon 11)
total xylene isomers	
Radiological activities	
Gross alpha	
Gross beta	

* Includes cis- and trans- 1,2-dichloroethene

2.4.3.2 Concentration Limits [22 CCR 66265.94]

For each COC specified and the background water quality parameters (see section 2.5.6), LLNL will determine a concentration limit not to exceed the background value from the first year of sampling.

2.4.3.3 Point of Compliance and all Monitoring Points [22 CCR 66265.95]

The point of compliance is defined as a vertical surface, located at the hydraulically downgradient limit of the waste management area, which extends through the uppermost aquifer underlying the burn facility. We are proposing a point of compliance located approximately 900 ft downgradient from the edge of the HE Open Burn Treatment Facility. This location will allow us to take advantage of two existing monitoring wells, W-827-05, and W-829-15. A new well location has been proposed (Figure 2.4.1) along the proposed point of compliance. These wells monitor (or will monitor) the regional aquifer downgradient of the unit.

Monitoring points along the point of compliance in the regional aquifer include existing wells W-827-05, W-829-15, and one proposed well. These wells are, or will be, downgradient of the facility. Well 827-04, which is shallow and is located adjacent to well W-827-05, will be annually monitored for the presence of ground water. If water is discovered, this well will be monitored according to the schedule for well W-827-05.

In addition to the above point of compliance monitoring locations screened in the regional aquifer, two existing wells, W-829-08 and W-829-06, are screened in the perched water zone beneath the HE Open Burn Treatment Facility. LLNL will monitor these wells to provide a continuing water quality assessment throughout the closure and post-closure periods.

Terrain conditions upgradient of HE Open Burn Treatment Facility do not allow the installation of an upgradient monitoring point. To establish background chemical concentrations, we propose using results from cross-gradient well W-827-05 and/or the proposed new well.

2.4.3.4 Compliance Period [22 CCR 66265.96]

The compliance period for the HE Open Burn Treatment Facility is specified to be a period equal to the active life of the facility (including the closure period). The compliance period constitutes the minimum period of time during which LLNL shall conduct a water quality monitoring program subsequent to the closure of the Open Burn Treatment Facility. This compliance period will begin each time when LLNL initiates an evaluation monitoring program (22 CCR 66265.99).

2.5 General Water Quality Monitoring and System Requirements [22 CCR 66265.97]

The ground water water monitoring system will be developed in accordance with 22 CCR 66265.97, specifics of the ground water monitoring system are discussed throughout the remainder of this section.

2.5.1 Monitoring Well Locations [22 CCR 66265.97(b)(1) and (2)]

We propose to use two existing wells and one new monitoring well for post-closure ground water monitoring in the vicinity of the HE Open Burn Treatment Facility (Fig. 2.4-1). All three wells monitor the regional aquifer downgradient of the facility and are located just upgradient of the Building 827 Complex. The wells are described in greater detail below.

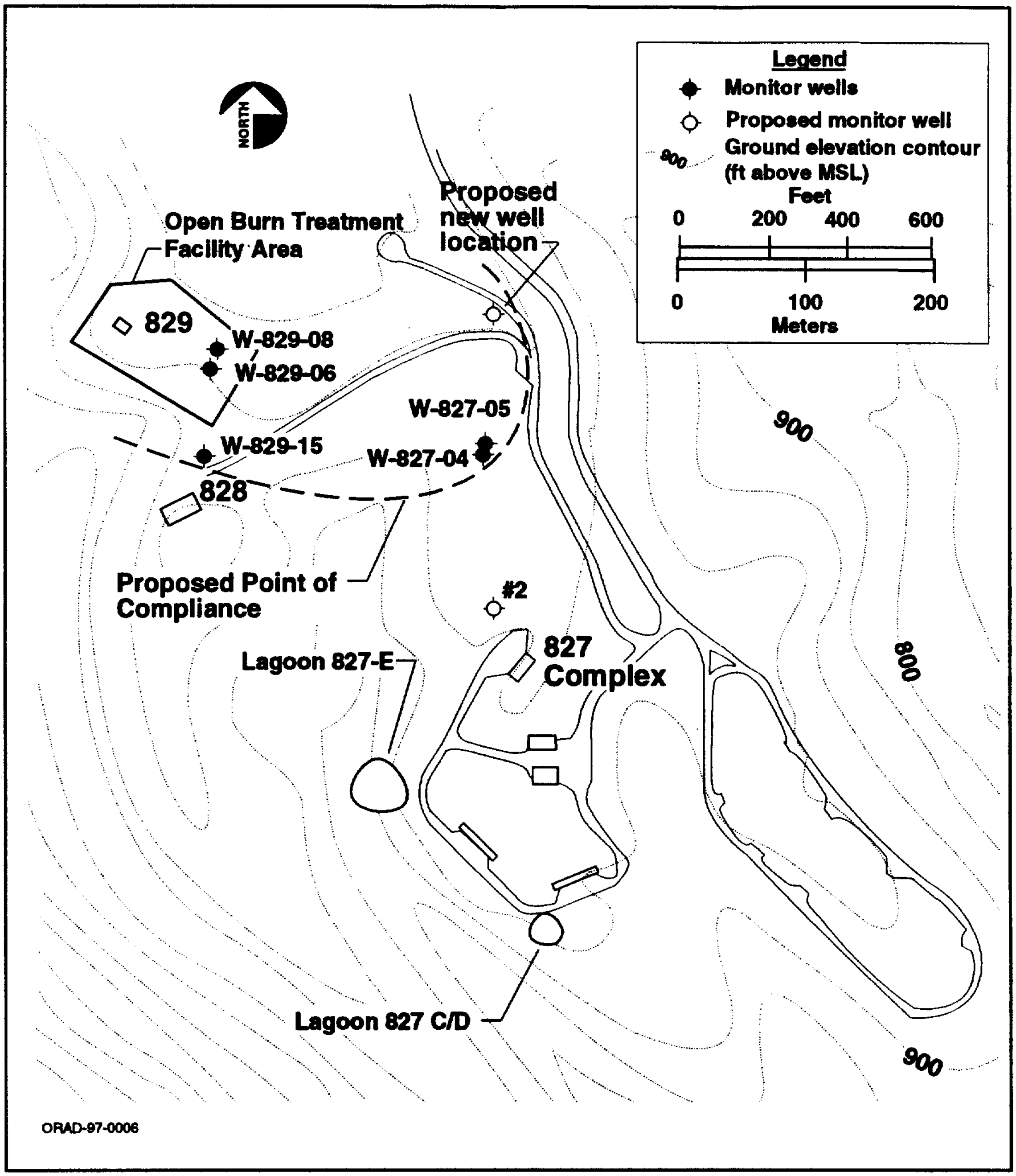

Figure 2.4-1. Post-closure monitor well locations, HE Open Burn Treatment Facility.

Two of the exploratory boreholes drilled for the HE Process Area Remedial Investigation were converted to monitoring wells: W-829-06 and W-829-08. Both wells are screened within the perched water-bearing zone beneath the burn pits, in fractured siltstone and claystone of the Neroly formation. The wells are located approximately in the downgradient direction from the burn pits, as inferred from the southeasterly dip of the Neroly strata (section 1.4.1). Table C-8 of Appendix C summarizes the potentiometric surface elevations in W-829-06 and W-829-08 since their construction in early 1988. Monitoring well construction information for W-829-06 and W-829-08 is summarized in Table 2.4-2. Sampling of W-829-06 began in December 1992. Well W-829-08 has been sampled quarterly since 1987, and the ground water samples have been analyzed for explosives compounds, metals, and VOCs. Ground water analytic data from wells W-829-06 and W-829-08 are presented in Appendix H . To provide a continuing water quality assessment of ground water from the uppermost aquifer, LLNL will continue to monitor the ground water in the vicinity of the facility throughout the closure and post-closure periods, however, these will not be points of compliance, nor will concentration limits be established. Samples will be taken quarterly for explosives compounds and VOCs.

Table 2.4-2. Well construction data for installations in the HE Open Burn Treatment Facility area.

	Well Designation				
	W-827-04	**W-827-05**	**W-829-06**	**W-829-08**	**W-829-15**
Type	MW	MW	MW	MW	MW
Shiner Elevation (ft/MSL)	1,031.12	1,031.38	1,069.29	1,071.75	1,032.0
POM Elevation (ft/MSL)	1,033.63	1,033.88	1,072.29	1,074.75	1,034.0
Depth of Screened Interval (ft)	297.60–307.50	379.0–408.5	76.00–98.00	89.50–109.50	382.2–392.2
Depth of Sand Pack Interval (ft)	292.00–307.50	376.0–411.0	70.50–99.00	83.50–109.50	378.0–393.2
Well Diameter I.D. (in.)	4.50	4.50	4.50	4.50	4.50
Casing Depth (ft)	307.5	410.0	98.00	109.50	393.2
Pump Intake Depth (ft)	NA	408.8	NA	105.00	392.9
Pump Type	No pump	Grundfos	No pump[a]	Well-Wizard	Grundfos 1hp
Date Completed	07/19/90	01/03/91	12/18/86	01/14/87	08/18/94

[a] Well sampled by Teflon bailer.

Well W-827-05 was installed in December 1990 and January 1991 to the northwest and upgradient of the Building 827 Complex (Fig. 1.3-1), about 1000 ft southeast and downgradient of the HE Open Burn Treatment Facility. This well was screened within the regional confined aquifer, from 379 to 408.5 ft of depth, to obtain evidence of the quality of regional ground water. Quarterly analytic results from well W-827-05 will be used to assess the water quality of regional ground water. Water level data and well construction data for W-827-05 are included in Tables C-8 and 2.4-2, respectively.

Well W-827-04, located adjacent to W-827-05 (Fig. 1.3-1), will be examined annually for the presence of ground water. If water is found, sampling will be initiated in accordance with the schedule for W-827-05.

W-829-15 was installed in July and August 1994, about 500 ft south of the burn pits (Fig. 2.4-1). The well was screened in the regional aquifer from a depth of 382 to 392 ft. Water level data, water quality data, and well construction data for W-827-05 are included in Tables C-8, H-1, and 2.4-2, respectively.

2.5.2 Well Construction [22 CCR 66265.97(b)(4), (5), (6), and (7)]

LLNL well drilling and installation procedures are consistent with those prescribed in *RCRA Ground Water Monitoring Technical Enforcement Guidance Document* (U.S. EPA, 1986) (see also *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs).* Monitoring wells that require replacement during the post-closure period will be constructed using the same materials and techniques as were used for installation of the original wells. Well construction procedures are described below.

Hollow-stem augering is used to drill shallow boreholes and unconsolidated deposits. Air-rotary and air-mist rotary drilling are used to drill deeper boreholes and consolidated materials. Continuous wireline coring is used to collect rock core with minimal disturbance. These methods prevent introduction of drilling fluids into the formation, which might compromise sample integrity.

Once a water-bearing zone is encountered, drilling continues until an underlying aquitard is encountered. Prior to casing emplacement, a bentonite plug is formed at the base of the borehole. Screened and blank polyvinyl chloride (PVC) casing is used to construct the well. The filter pack consists of Monterey #0 and #3 sand. The sampled zone is overlain by a bentonite seal; cement grout seals the annular space to the surface. Additional grout is used to create a pad for emplacement of a locked steel well-head protector to provide stability and security.

In multiple completion installations and wells tapping deeper aquifers, special drilling and installation methods are used to prevent cross-contamination or mixing of water from separate aquifer zones. After drilling to the top of the aquitard beneath the first aquifer, casing is placed within the borehole. A grout plug is poured into the borehole and is allowed to circulate both inside and outside of the casing. Before drilling through the grout seal, all standing water in the casing is removed so that the first aquifer is sealed off. Drilling then resumes until an aquitard underlying the second aquifer is encountered. Either this procedure is repeated to reach the next water-bearing zone, or the sampling zone is completed within this second aquifer.

Information on construction of the existing ground water monitoring wells proposed for post-closure monitoring of the facility is summarized in Table 2.4-2. This information includes well diameters and depths, screen intervals, and types of pumps installed. Wells have been completed with screw-coupled, potable-grade PVC casing with 0.02-in. slotted screens. Figure 2.4-2 shows a typical monitoring well. Graphic well log summaries for monitoring wells at the HE Open Burn Treatment Facility and Building 827 Complex are presented in Appendix B.

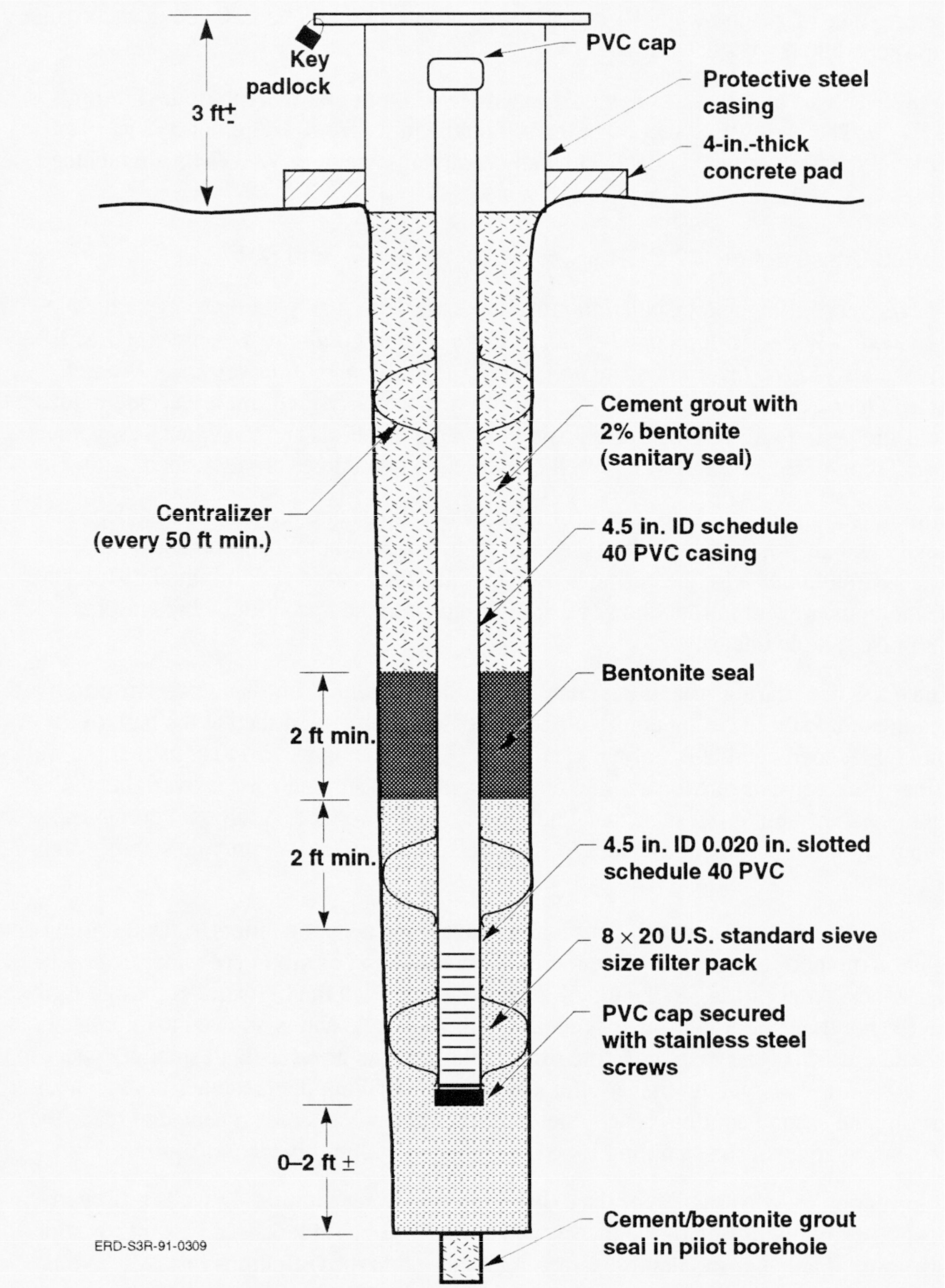

Figure 2.4-2. Typical monitor well/piezometer.

2.5.3 Sampling and Analysis Procedures [22 CCR 66265.97(e) (4) and (5)]

Sampling, testing, and screening procedures are covered under the Site 300 Restoration Section QAPP Chapter 5 (Sampling Procedures), Chapter 7 (Calibration Procedures), and Chapter 8 (Analytical Procedures), as well as under the *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs).*

Details of these procedures are not included in this document. Procedures are updated as needed based on revisions to regulatory guidance and analytical requirements. Current procedures are available upon request. The following SOPs or their subsequent revisions will be used to ensure consistent sampling and analyltical procedures that are designed to provide monitoring results that provide a reliable indication of water quality at all monitoring points.

SOP	Title
1.2	Borehole Sampling of Unconsolidated Sediments and Rocks
1.9	Suction Lysimeter Soil Moisture Sampling
1.10	Soil Vapor Surveys
2.1	Presample Purging of Wells
2.2	Field Measurements on Surface and Ground Waters
2.3	Sampling Monitor Wells with Bladder and Electic Submersible Pumps
2.4	Sampling Monitor Wells with a Bailer
2.6	Sampling for Volatile Organic Compounds
2.7	Presample Purging of Low Yield Wells
2.8	Installation of Dedicated Sampling Pumps
2.9	Sampling Ground Water for Tritium
2.10	Well Disinfection and Coliform Sampling
2.12	Ground Water Monitor Wells and Equipment Maintenance
3.1	Water-level Measurements
4.2	Sample Control and Documentation
4.3	Sample Containers and Preservation
4.4	Guide to Handling, Packaging, and Shipping of Samples
4.5	General Equipment Decontamination
4.8	Calibration/Verification and Maintenance of Field Instruments Used in Measuring Parameters of Surface Water, Ground Water and Soils

Samples will be analyzed by state-certified laboratories. LLNL periodically updates its contracts with analytical laboratories and ensures that the most current EPA methods that meet the data objectives, such as reporting limits, are used.

2.5.4 Establishment of Background Conditions [22 CCR 66265.97(e) (6)]

Because of the steep, semi-mountainous terrain present northwest of the HE Open Burn Treatment Facility, installation of a hydrologically upgradient monitoring well is impractical. Therefore, baseline water quality assessment of the perched water-bearing zone will be provided by analytical ground water data from well W-829-08. Monitoring of well W-829-08 for VOCs and explosives compounds has continued on a quarterly basis since the well was installed in January 1987. Results of historical analyses for W-829-08 are contained in *LLNL Site 300 Environmental Investigations Quarterly Reports* and are presented here in Appendix H. The individual monitoring results for these parameters will be used for background. Explosives compounds have never been detected in ground water samples from W-829-08. TCE has been detected periodically in concentrations over the DTSC MCL of 5 µg/L. Dichlorodifluoromethane, and Freon-113 have also been detected in ground water samples from this monitoring well at low concentrations.

Individual parameter ground water monitoring results from well W-827-05 are used as baseline data for the regional aquifer. Samples for explosives compounds and VOCs, and metals have been taken from W-827-05. Tables C-4, C-5, and C-6 of Appendix C and Table H-1 from Appendix H provide analytical data obtained from W-827-05. 1,1,1-Trichloroethane, carbon disulfide, ethylbenzene, toluene and total xylene isomers have been detected in samples from this ground water monitor well. Explosive compounds have not been detected in this well.

2.5.5 Methods to Establish Background Values [22 CCR 66265.97(e) (12)]

A background value will be determined using data from the background monitoring location well for each COC. Each set of samples will consist of four samples taken at an interval that assures, to the greatest extent technically feasible, that an independent sample is obtained [22 CCR 66265(e)(12)(B)]. The background value for COCs will be calculated from the results of single samples collected at least quarterly. If resources permit, single samples will be collected monthly. The monthly sampling, if performed, will (1) ensure that samples will be collected during the times of highest and lowest ground water elevation [22 CCR 66265.97(e)(6)], (2) more precisely establish the background values, (3) help determine if seasonal variation and temporal correlation are present [22 CCR 66265(e)(9)(F)].

When all analytical results are above the limit of detection, the background values will be the mean and standard deviation of the sample analytical results. When some analytical results are below the limit of detection, background values will be calculated based on guidance in U.S. EPA (1992), Section 5.1.2.2.1, "Evaluation of Censored Data Sets." Although this document addresses exposure assessment, the discussion of censored data sets is general and applicable to any data set.

Monitoring at the background monitoring point location will continue after the initial year of sampling, using the same sampling frequency as the monitoring point locations (see section 2.4.2.3). Background values will be updated annually. The exact manner of updating will depend on the kind of variation, if any, exhibited by the background data [22 CCR 66265.97(e)(10)(B) and (11)(B)].

2.5.6 Background Water Quality Parameters [22 CCR 66265.97(e) (16)]

Additionally, we will establish background water quality concentrations for the parameters (Table 2.4-3) required in 22 CCR 66265.97(e)(16) by sampling as least quarterly for a period of one year to establish background concentrations at the background monitoring point.The compliance period for the Open Burn Treatment Facility is discussed in section 2.4.2.4.

Table 2.4-3. Background water quality parameters.

- Arsenic
- Barium
- Cadmium
- Chloride
- Chromium
- Coliform Bacteria
- Endrin
- Fluoride
- Gross Alpha
- Gross Beta
- Iron
- Lead
- Lindane
- Manganese
- Mercury
- Methoxychlor
- Nitrate as N
- pH
- Phenols
- Radium
- Selenium
- Silver
- Sodium
- Specific Conductance
- Sulfate
- Toxaphene
- 2,4-D
- 2,4,5 TP Silvex
- Total Organic Carbon
- Total Organic Halogen
- Turbidity

2.6 Recordkeeping and Reporting [22 CCR 66265.97(e) (17)]

The storage of all QA records is described in the LLNL Environmental Restoration Division's Data Management Standard Operationg Procedures that are currently in draft. Analytical results, including ground water elevations, will be kept by the Environmental Protection Department at the LLNL Livermore site. After publication, duplicate copies of analytical results will also be maintained at Site 300.

The data gathered through this program will be reported annually (no later than March 1 of the following calendar year) or as required by the regulatory agencies and in the site annual environmental report published each year by LLNL.

2.7 Detection Monitoring Program [22 CCR 66265.98]

2.7.1 Ground Water Monitoring Parameters [22 CCR 66265.98 (f)]

The general monitoring parameters will not be monitored. Based on historical activities, analysis of waste ash, soil borings, and ground water monitoring data, more than 30 COCs have been selected for post-closure ground water monitoring of the HE Open Burn Treatment Facility. These site-specific COCs are more likely to provide early detection of a release than general indicator parameters such as those listed in 22 CCR 66265.98(f). In addition, LLNL has attempted to find correlation between indicator parameters and COCs, and we have been unable to demonstrate that any of the potential indicators are sufficiently correlated with any of the COCs to provide a reliable indication of a potential release. These comparisons have been made using data collected from the post-closure monitoring program for Pits 1 and 7. For example, our most thorough statistical study of correlation between indicators and constituents examined calcium, chloride, sodium, sulfate, total dissolved solids and specific conductance (Fisher *et al.*, 1992). In this particular investigation it took 3 dependent variables together (calcium, chloride and sulfate) to account for only 38% of the variation in the dependent variable (specific conductance). Therefore indicator parameters are not appropriate as monitoring parameters, and LLNL will substitute site-specific COCs for post-closure monitoring.

2.7.2 Sampling Frequencies [22 CCR 66265.98 (g)]

Based on LLNL's historical monitoring program, as reported in its quarterly and annual environmental reports, LLNL has developed the following program for post-closure ground water monitoring of the aquifers beneath the HE Open Burn Treatment Facility.

1. Sampling of wells W-829-06 and W-829-08, screened in the perched water-bearing zone beneath the HE Open Burn Treatment Facility.
    - Quarterly sampling and analysis of the following constituents:
        — Purgeable Halocarbons
        — Explosives Compounds HMX, RDX, and TNT
2. Sampling of wells W-827-05, W-829-15 and the proposed new well, screened in the regional aquifer downgradient of the HE Open Burn Treatment Facility.

    A. Establishment of background water quality, well W-829-05

    Quarterly sampling for the first year only to establish the background water quality for the parameters list in Table 2-4-3 that are required by 22CCR66265.97(e)

    B. Establishment of statistical limits for wells W-827-05, W-829-15, and the proposed new well

    Sampling as required to establish the required statistically based limits for the constituents of concern specified in Table 2-4-1

C. On-going monitoring, wells W-827-05, W-829-15, and the proposed new well

Sampling frequency required by the statistical method selected for each constituent of concern specified in Table 2.4-1.

Elevations of the potentiometric surface will be recorded each time a well is sampled or at least once a quarter. This information will be used to construct contour maps to evaluate hydraulic gradients and to calculate seepage velocities within the regional aquifer.

If water is detected in W-827-04, sampling will be initiated in accordance with the sampling schedule outlined for W-827-05.

After the first year of samples has been collected, statistical analyses will be performed to compare monitoring point concentrations with background concentrations. The statistical method will be performed in accordance with the methods and frequencies listed in 22 CCR 66265.98(g) and (h).

LLNL anticipates that the prediction interval method with retests will be an appropriate statistical method. However, 22 CCR 265.97(e)(7) states that the selection of statistical method is to be based on data collected during the initial year of background sample collection. It may therefore be necessary for LLNL to select a different statistical method after the first year of sampling. If so, the method will be selected in accordance with 22 CCR 66265.97(e)(7), (e)(8), and (e)(9).

Prediction intervals will be calculated at a significance level calculated by the formula in 22 CCR 66265.97(e)(8)(E)6. The number of discrete retests will normally be two; an initial sample result outside the prediction interval will be considered statistically significant if any of the retests is also outside the prediction interval.

2.7.2.1 Reduction of Sampling Frequency

At each background and monitoring point well, after one year of detection monitoring, the number of detections and non-detections will be tabulated. Any constituent of concern that has not been detected in any sample at any well will have its sampling frequency reduced from quarterly to semi-annually at all wells.

Different monitoring parameters and constituents of concern may have different sampling frequencies, but each parameter or constituent will have the same sampling frequency at all wells.

Appendix C

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Appendix A

Appendix A.

Waste Analysis

Table A-1. Waste ash analyses for metals (mg/L) from the HE Open Burn Treatment Facility.

	Sample date:	08/14/89	08/14/89	08/22/90	08/22/90	
	Sample I.D.:	890-00-896	890-00-896	9001800	9001801	
	Extraction method:	EP TOX	WET	WET	WET	
EPA Method No.	Analyte					STLC
6010	Antimony	NA	2.2	<0.05	<0.05	15
6010	Arsenic	<0.1	0.9	NA	NA	5.0
6010	Barium	<0.1	15	2.0	20	100
6010	Beryllium	NA	<0.05	0.005	0.016	0.75
6010	Cadmium	<0.05	0.86	0.18	0.60	1.0
7196	Chromium VI	NA	NA	NA	NA	5.0
6010	Chromium	<0.1	0.9	1.9	3.2	560
6010	Cobalt	NA	0.7	22	0.57	80
6010	Copper	NA	7.2	9.5	120	25
6010	Lead	<0.1	5.1	4.9	48	5.0
7470	Mercury	<0.01	<0.01	NA	NA	0.2
6010	Molybdenum	NA	1.1	<0.05	0.05	350
6010	Nickel	NA	1.0	1.1	1.1	20
6010	Selenium	<0.1	0.18	NA	NA	1.0
6010	Silver	<0.1	<0.1	0.24	0.09	5
6010	Thallium	NA	<0.1	<0.05	<0.05	7.0
6010	Vanadium	NA	0.7	0.69	0.77	24
6010	Zinc	NA	120	27	84	250

Abbreviations:

< = Less Than, Below Limit of Detection

NA = Not Analyzed

EP TOX = Extraction Procedure Toxicity Test, EPA 1310, SW-846, 2nd Edition.

STLC = Soluble Threshold Limit Concentration, Title 22 CCR, Section 66693.

WET = Waste Extraction Test, Title 22 CCR, Section 66700

Table A-2. Waste ash analyses for VOCs (μg/kg) from the HE Open Burn Treatment Facility.

	Sample date:	08/22/90	8/22/90	
	Sample I.D.:	9001800	9001801	
EPA Method No.	Analyte			DTL
8240	Benzene	<2	40	100
8240	Ethylbenzene	<3	30	68,000
8240	1,1,1-Trichloroethane	4	1,000	20,000
8240	Tetrachloroethane	23	780	—
8240	Toluene	3	130	200,000

< = less than, below limit of detection

8240 = EPA Method 8240, Total Fuel and Aromatic Volatile Hydrocarbons

DTL = Designated Threshold Level

Table A-3. Metals analysis results—ash.

Compound	Type of analysis	Method number	Method concentration	Detection limit	Sample ID number	Sample date
Antimony	STLC	6010	ND	<0.9 mg/L	9100230	2/11/91
	STLC	6010	0.9 mg/L	<0.8 mg/L	9200469	2/24/92
	TCLP	6010	<0.6 mg/L	<0.5 mg/L	9100991	5/29/91
	TCLP	6010	ND	<2.0 mg/L	9101832	9/17/91
	TCLP	6010	3.0 mg/L	<0.8 mg/L	9200469	2/24/92
	TCLP	6010	ND	<2.0 mg/L	9201082	4/29/92
	TCLP	6010	ND	<0.6 mg/L	9203270	11/17/92
	TCLP	6010	1.0 mg/L	<0.6 mg/L	9203339	11/30/92
	TTLC	6010	ND	<80.0 mg/kg	9201082	4/29/92
	TTLC	6010	60.0 mg/kg	<30.0 mg/kg	9203270	11/17/92
Arsenic	STLC	7061	0.16 mg/L	<0.001 mg/L	9100230	2/11/91
	STLC	7061	0.11 mg/L	<0.003 mg/L	9200469	2/24/92
	TCLP	7061	ND	<0.001 mg/L	9100230	2/11/91
	TCLP	7061	0.004 mg/L	<0.003 mg/L	9101832	9/17/91
	TCLP	7061	0.01 mg/L	<0.003 mg/L	9200469	2/24/92
	TCLP	7061	ND	<0.001 mg/L	9201082	4/29/92
	TCLP	7061	ND	<152.0 µg/L	9402149	7/14/94
	TCLP	7061	ND	<211.0 µg/L	9403244	10/24/94
	TCLP	7060	ND	<0.03 mg/L	9500122	1/20/95
	TCLP	7060	ND	<0.14 mg/L	9501862	6/2/95
Barium	STLC	6010	27.0 mg/L	<0.0009 mg/L	9100230	2/11/91
	STLC	6010	9.9 mg/L	<0.1 mg/L	9100991	5/29/91
	STLC	6010	9.9 mg/L	<0.001 mg/L	9200469	2/24/92
	TCLP	6010	2.8 mg/L	<0.0008 mg/L	9100991	5/29/91
	TCLP	6010	2.8 mg/L	<0.002 mg/L	9101832	9/17/91
	TCLP	6010	0.88 mg/L	<0.001 mg/L	9200469	2/24/92
	TCLP	6010	2.8 mg/L	<0.003 mg/L	9201082	4/29/92
	TCLP	6010	3.2 mg/L	<0.001 mg/L	9203270	11/17/92
	TCLP	6010	2.3 mg/L	<0.0009 mg/L	9203339	11/30/92
	TCLP	6010	591.0 µg/L[a]	2.8 µg/L	9402149	7/14/94
	TCLP	6010	1140.0 µg/L	1.6 µg/L	9403244	10/24/94
	TCLP	6020	2.0 mg/L	<0.02 mg/L	9500122	1/20/95
	TCLP	6010	655 µg/L	<0.02 mg/L	9501862	6/2/95
	TTLC	6010	22.0 mg/kg	<0.1 mg/kg	9201082	4/29/92

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Table A-3. (continued)

Compound	Type of analysis	Method number	Method concentration	Detection limit	Sample ID number	Sample date
Barium (cont.)	TTLC	6010	1200.0 mg/kg	<0.05 mg/kg	9203270	11/17/92
Beryllium	STLC	6010	0.037 mg/L	<0.003 mg/L	9100230	2/11/91
	STLC	6010	ND	<0.05 mg/L	9100991	5/29/91
	STLC	6010	0.11 mg/L	<0.004 mg/L	9200469	2/24/92
	TCLP	6010	<0.0017 mg/L	<0.0016 mg/L	9100991	5/29/91
	TCLP	6010	0.004 mg/L	<0.0013 mg/L	9101832	9/17/91
	TCLP	6010	0.01 mg/L	<0.004 mg/L	9200469	2/24/92
	TCLP	6010	ND	<0.003 mg/L	9201082	4/29/92
	TCLP	6010	ND	<0.003 mg/L	9203270	11/17/92
	TCLP	6010	ND	<0.004 mg/L	9203339	11/30/92
	TTLC	6010	0.8 mg/kg	<0.3 mg/kg	9201082	4/29/92
	TTLC	6010	0.4 mg/kg	<0.1 mg/kg	9203270	11/17/92
Cadmium	STLC	6010	0.2 mg/L	<0.03 mg/L	9100230	2/11/91
	STLC	6010	0.19 mg/L	<0.05 mg/L	9100991	5/29/91
	STLC	6010	0.02 mg/L	<0.03 mg/L	9200469	2/24/92
	TCLP	6010	0.04 mg/L	<0.02 mg/L	9100991	5/29/91
	TCLP	6010	ND	<0.018 mg/L	9101832	9/17/91
	TCLP	6010	0.07 mg/L	<0.03 mg/L	9200469	2/24/92
	TCLP	6010	0.1 mg/L	<0.02 mg/L	9201082	4/29/92
	TCLP	6010	0.1 mg/L	<0.02 mg/L	9203270	11/17/92
	TCLP	6010	0.1 mg/L	<0.03 mg/L	9203339	11/30/92
	TCLP	6010	83.4 µg/L	8.8 µg/L	9402149	7/14/94
	TCLP	6010	48.3 µg/L	14.8 µg/L	9403244	10/24/94
	TCLP	6020	2.1 mg/L	<0.02 mg/L	9500122	1/20/95
	TCLP	6010	386 µg/L	<0.02 mg/L	9501862	6/2/95
	TTLC	6010	2.0 mg/kg	<1.0 mg/kg	9201082	4/29/92
	TTLC	6010	17.0 mg/kg	<1.0 mg/kg	9203270	11/17/92
Chromium	STLC	6010	0.36 mg/L	<0.004 mg/L	9100230	2/11/91
	STLC	6010	0.2 mg/L	<0.1 mg/L	9100991	5/29/91
	STLC	6010	2.7 mg/L	<0.005 mg/L	9200469	2/24192
	TCLP	6010	0.005 mg/L	<0.003 mg/L	9100991	5/29/91
	TCLP	6010	0.007 mg/L	<0.006 mg/L	9101832	9/17/91
	TCLP	6010	0.02 mg/L	<0.005 mg/L	9200469	2/24/92
	TCLP	6010	ND	<0.006 mg/L	9201082	4/29/92

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Table A-3. (continued)

Compound	Type of analysis	Method number	Method concentration	Detection limit	Sample ID number	Sample date
Chromium	TCLP	6010	0.01 mg/L	<0.004 mg/L	9203270	11/17/92
(continued)	TCLP	6010	0.03 mg/L	<0.005 mg/L	9203339	11/30/92
	TCLP	6010	ND	<12.0 µg/L	9402149	7/14/94
	TCLP	6010	722.0 µg/L	13.6 µg/L	9403244	10/24/94
	TCLP	6020	ND	0.1 mg/L	9500122	1/20/95
	TTLC	6010	70.0 mg/kg	<0.4 mg/kg	9201082	4/29/92
	TTLC	6010	1700.0 mg/kg	<0.2 mg/kg	9203270	11/17/92
	TCLP	6010	<0.03 mg/L	<0.03 mg/L	9501862	6/2/95
Cobalt	STLC	6010	0.23 mg/L	<0.02 mg/L	9100230	2/11/91
	STLC	6010	0.34 mg/L	<0.03 mg/L	9200469	2/24/92
	TCLP	6010	0.04 mg/L	<0.019 mg/L	9100991	5/29/91
	TCLP	6010	ND	<0.03 mg/L	9101832	9/17/91
	TCLP	6010	ND	<0.03 mg/L	9200469	2/24/92
	TCLP	6010	0.07 mg/L	<0.03 mg/L	9201082	4/29/92
	TCLP	6010	0.06 mg/L	<0.02 mg/L	9203270	11/17/92
	TCLP	6010	0.1 mg/L	<0.02 mg/L	9203339	11/30/92
	TTLC	6010	30.0 mg/kg	<2.0 mg/kg	9201082	4/29/92
	TTLC	6010	34.0 mg/kg	<1.0 mg/kg	9203270	11/17/92
Copper	STLC	6010	ND	<0.005 mg/L	9100230	2/11/91
	STLC	6010	2.8 mg/L	<0.1 mg/L	9100991	5/29/91
	STLC	6010	0.063 mg/L	<0.004 mg/l	9200469	2/24/92
	TCLP	6010	0.12 mg/L	<0.004 mg/L	9100991	5/29/91
	TCLP	6010	0.49 mg/L	<0.006 mg/L	9101832	9/17/91
	TCLP	6010	2.3 mg/L	<0.004 mg/L	9200469	2/24/92
	TCLP	6010	ND	<0.006 mg/L	9201082	4/29/92
	TCLP	6010	0.75 mg/L	<0.003 mg/L	9203270	11/17/92
	TCLP	6010	0.71 mg/L	<0.004 mg/L	9203339	11/30/92
	TTLC	6010	370.0 mg/kg	<0.3 mg/kg	9201082	4/29/92
	TTLC	6010	5900.0 mg/kg	<20.0 mg/kg	9203270	11/17/92
Lead	STLC	6010	7.6 mg/L	<0.06 mg/L	9100230	2/11/91
	STLC	6010	2.0 mg/L	<0.1 mg/L	9100991	5/29/91
	STLC	6010	4.0 mg/L	<0.05 mg/L	9200469	2/24/92
	TCLP	6010	<0.06 mg/L	<0.04 mg/L	9100991	5/29/91
	TCLP	6010	ND	<0.12 mg/L	9101832	9/17/91

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Table A-3. (continued)

Compound	Type of analysis	Method number	Method concentration	Detection limit	Sample ID number	Sample date
Lead	TCLP	6010	0.2 mg/L	<0.05 mg/L	9200469	2/24/92
(continued)	TCLP	6010	ND	<0.1 mg/L	9201082	4/29/92
	TCLP	6010	0.2 mg/L	<0.03 mg/L	9203270	11/17/92
	TCLP	6010	48.0 mg/L	<0.04 mg/L	9203339	11/30/92
	TCLP	6010	185.0 µg/L[a]	105.2 µg/L	9402149	7/14/94
	TCLP	6010	860.0 µg/L	169.2 µg/L	9403244	10/24/94
	TCLP	6020	0.21 mg/L	<0.02 mg/L	9500122	1/20/95
	TCLP	6010	<1 mg/L	< 1 mg/L	95501862	6/2/95
	TTLC	6010	5900.0 mg/kg	<7.0 mg/kg	9201082	4/29/92
	TTLC	6010	1000.0 mg/kg	<2.0 mg/kg	9203270	11/17/92
Manganese	STLC	6010	16.0 mg/L	<0.011 mg/L	9100230	2/11/91
	STLC	6010	41.0 mg/L	<0.007 mg/L	9200469	2/24/92
	TCLP	6010	3.9 mg/L	<0.006 mg/L	9100991	5/29/91
	TCLP	6010	1.8 mg/L	<0.006 mg/L	9101832	9/17/91
	TCLP	6010	3.9 mg/L	<0.007 mg/L	9200469	2/24/92
	TCLP	6010	3.5 mg/L	<0.005 mg/L	9201082	4/29/92
	TCLP	6010	4.9 mg/L	<0.006 mg/L	9203270	11/17/92
	TCLP	6010	3.7 mg/L	<0.007 mg/L	9203339	11/30/92
	TTLC	6010	120.0 mg/kg	<0.4 mg/kg	9201082	4/29/92
	TTLC	6010	2300.0 mg/kg	<0.3 mg/kg	9203270	11/17/92
Mercury	STLC	7470	ND	<0.005 mg/L	9100230	2/11/91
	STLC	7470	ND	<0.01 mg/L	9100991	5/29/91
	STLC	7470	ND	<0.006 mg/L	9200469	2/24/92
	TCLP	7470	ND	<0.003 mg/L	9100230	2/11/91
	TCLP	7470	ND	<0.003 mg/L	9100991	5/29/91
	TCLP	7470	0.006 mg/L	<0.003 mg/L	9101832	9/17/91
	TCLP	7470	ND	<0.006 mg/L	9200469	2/24/92
	TCLP	7470	ND	<0.003 mg/L	9201082	4/29/92
	TCLP	7470	ND	<0.003 mg/L	9203270	11/17/92
	TCLP	7470	ND	<0.003 mg/L	9203339	11/30/92
	TCLP	7470	ND	<1.0 µg/L	9402149	7/14/94
	TCLP	7470	ND	<1.0 µg/L	9403244	10/24/94
	TCLP	7470	ND	< 1.0 µg/L	9500122	1/20/95
	TCLP	7470	ND	<1.0 µg/L	9501862	6/2/95
	TTLC	7470	9.9 mg/kg	<0.1 mg/kg	9203270	11/17/92
Molybdenum	STLC	6010	0.67 mg/L	<0.003 mg/L	9100230	2/11/91

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Table A-3. (continued)

Compound	Type of analysis	Method number	Method concentration	Detection limit	Sample ID number	Sample date
Molybdenum	STLC	6010	2.9 mg/L	<0.004 mg/L	9200469	2/24/92
(continued)	TCLP	6010	1.6 mg/L	<0.003 mg/L	9100991	5/29/91
	TCLP	6010	0.087 mg/L	<0.005 mg/L	9101832	9/17/91
	TCLP	6010	0.19 mg/L	<0.004 mg/L	9200469	2/24/92
	TCLP	6010	0.072 mg/L	<0.005 mg/L	9201082	4/29/92
	TCLP	6010	0.24 mg/L	<0.003 mg/L	9203270	11/17/92
	TCLP	6010	0.16 mg/L	<0.004 mg/L	9203339	11/30/92
	TTLC	6010	20.0 mg/kg	<0.3 mg/kg	9201082	4/29/92
	TTLC	6010	140.0 mg/kg	<0.2 mg/kg	9203270	11/17/92
Nickel	STLC	6010	1.0 mg/L	<0.008 mg/L	9100230	2/11/91
	STLC	6010	0.6 mg/L	<0.1 mg/L	9100991	5/29/91
	STLC	6010	2.3 mg/L	<0.009 mg/L	9200469	2/24/92
	TCLP	6010	0.11 mg/L	<0.007 mg/L	9100991	5/29/91
	TCLP	6010	0.03 mg/L	<0.009 mg/L	9101832	9/17/91
	TCLP	6010	0.02 mg/L	<0.009 mg/L	9200469	2/24/92
	TCLP	6010	0.1 mg/L	<0.01 mg/L	9201082	4/29/92
	TCLP	6010	1.2 mg/L	<0.007 mg/L	9203270	11/17/92
	TCLP	6010	0.5 mg/L	<0.008 mg/L	9203339	11/30/92
	TTLC	6010	190.0 mg/kg	<0.5 mg/kg	9201082	4/29/92
	TTLC	6010	1200.0 mg/kg	<0.4 mg/kg	9203270	11/17/92
Selenium	STLC	7741	0.008 mg/L	<0.001 mg/L	9100230	2/11/91
	STLC	7741	ND	<0.003 mg/L	9200469	2/24/92
	TCLP	7741	0.010 mg/L	<0.001 mg/L	9100230	2/11/91
	TCLP	7741	0.02 mg/L	<0.003 mg/L	9101832	9/17/91
	TCLP	7741	ND	<0.003 mg/L	9200469	2/24/92
	TCLP	7741	0.007 mg/L	<0.001 mg/L	9201082	4/29/92
	TCLP	7741	ND	<147.0 µg/L	9402149	7/14/94
	TCLP	7741	ND	<246.0 µg/L	9403244	10/24/94
	TCLP	7740	0.04 mg/L	<0.03 mg/L	9500122	1/20/95
	TCLP	7741	ND	<0.15 mg/L	9501862	6/2/95
Silver	STLC	6010	ND	<0.007 mg/L	9100230	2/11/91
	STLC	6010	ND	<0.1 mg/L	9100991	5/29/91
	STLC	6010	ND	<0.006 mg/L	9200469	2/24/92
	TCLP	6010	ND	<0.005 mg/L	9100991	5/29/91
	TCLP	6010	ND	<0.005 mg/L	9101832	9/17/91
	TCLP	6010	0.04 mg/L	<0.006 mg/L	9200469	2/24/92

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Table A-3. (continued)

Compound	Type of analysis	Method number	Method concentration	Detection limit	Sample ID number	Sample date
Silver	TCLP	6010	ND	<0.006 mg/L	9201082	4/29/92
(continued)	TCLP	6010	ND	<0.003 mg/L	9203270	11/17/92
	TCLP	6010	ND	<0.006 mg/L	9203339	11/30/92
	TCLP	6010	ND	<12.0 µg/L	9402149	7/14/94
	TCLP	6010	ND	<14.8 µg/L	9403244	10/24/94
	TTLC	6010	93.0 mg/kg	<0.3 mg/kg	9201082	4/29/92
	TTLC	6010	2.0 mg/kg	<0.3 mg/kg	9203270	11/17/92
	TCLP	6010	ND	<16.4 µg/L	9501862	6/2/95
Thallium	STLC	6010	0.03 mg/L	<0.015 mg/L	9100230	2/11/91
	STLC	6010	0.03 mg/L	<0.02 mg/L	9200469	2/24/92
	TCLP	6010	0.04 mg/L	<0.013 mg/L	9100991	5/29/91
	TCLP	6010	ND	<0.02 mg/L	9101832	9/17/91
	TCLP	6010	ND	<0.02 mg/L	9200469	2/24/92
	TCLP	6010	ND	<0.02 mg/L	9201082	4/29/92
	TCLP	6010	ND	<0.02 mg/L	9203270	11/17/92
	TCLP	6010	0.04 mg/L	<0.02 mg/L	9203339	11/30/92
	TTLC	6010	ND	<1.0 mg/kg	9201082	4/29/92
	TTLC	6010	1.0 mg/kg	<0.8 mg/kg	9203270	11/17/92
Vanadium	STLC	6010	0.61 mg/L	<0.006 mg/L	9100230	2/11/91
	STLC	6010	0.77 mg/L	<0.01 mg/L	9200469	2/24/92
	TCLP	6010	<0.008 mg/L	<0.006 mg/L	9100991	5/29/91
	TCLP	6010	ND	<0.011 mg/L	9101832	9/17/91
	TCLP	6010	ND	<0.01 mg/L	9200469	2/24/92
	TCLP	6010	ND	<0.01 mg/L	9201082	4/29/92
	TCLP	6010	ND	<0.008 mg/L	9203270	11/17/92
	TCLP	6010	ND	<0.009 mg/L	9203339	11/30/92
	TTLC	6010	13.0 mg/kg	<0.9 mg/kg	9201082	4/29/92
	TTLC	6010	40.0 mg/kg	<0.5 mg/kg	9203270	11/17/92
Zinc	STLC	6010	52.0 mg/L	<0.10 mg/L	9100230	2/11/91
	STLC	6010	90.0 mg/L	<0.1 mg/L	9100991	5/29/91
	STLC	6010	120.0 mg/L	<0.09 mg/L	9200469	2/24/92
	TCLP	6010	44.0 mg/L	<0.06 mg/L	9100991	5/29/91
	TCLP	6010	2.1 mg/L	<0.06 mg/L	9101832	9/17/91
	TCLP	6010	29.0 mg/L	<0.09 mg/L	9200469	2/24/92

continued on next page

Table A-3. (continued)

Compound	Type of analysis	Method number	Method concentration	Detection limit	Sample ID number	Sample date
Zinc	TCLP	6010	1.2 mg/L	<0.06 mg/L	9201082	4/29/92
(continued)	TCLP	6010	99.0 mg/L	<0.09 mg/L	9203339	11/30/92
	TCLP	6010	25.0 mg/L	<0.07 mg/L	9203270	11/17/92
	TTLC	6010	5400.0 mg/kg	<9.0 mg/kg	9201082	4/29/92
	TTLC	6010	4400.0 mg/kg	<3.0 mg/kg	9203270	11/17/92

[a] indicates analyte found is blank as well as sample.

ND = Not detected at or above limit of detection.
STLC = Soluble Threshold Limit Concentration
TCLP = Toxicity Characteristic Leaching Procedure
TTLC = Total Threshold Limit Concentration

Table A-4. Volatile Organic Compounds analysis results—ash .

Compound	Extraction concentration	Limit of detection	Sample ID number	Sample date
Acetone	0.1 mg/L	0.1 mg/L	9100991	5/29/91
	ND	0.2 mg/L	9101832	9/17/91
	70.0 µg/L	70.0 µg/L	9203270	11/17/92
	ND	70.0 µg/L	9203339	11/30/92
	200.0 µg/L[a]	100.0 µg/L	9402149	7/14/94
	ND	100.0 µg/L	9403244	10/24/94
	ND	0.2 mg/L	9501862	6/2/95
Benzene	ND	0.003 mg/L	9100991	5/29/91
	ND	0.02 mg/L	9101832	9/17/91
	ND	0.02 mg/L	9200469	2/24/92
	ND	0.02 mg/L	9201082	4/29/92
	5.0 µg/L	2.0 µg/L	9203270	11/17/92
	5.0 µg/L	2.0 µg/L	9203339	11/30/92
	ND	5.0 µg/L	9402149	7/14/94
	7.0 µg/L	5.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9500122	1/20/95
	ND	8.0 µg/L	9501862	6/2/95
Carbon tetrachloride	ND	3.0 µg/L	9203339	11/30/92
	ND	0.003 mg/L	9100991	5/29/91
	ND	0.02 mg/L	9200469	2/24/92
	ND	0.02 mg/L	9201082	4/29/92
	ND	3.0 µg/L	9203270	11/17/92
	ND	5.0 µg/L	9402149	7/14/94
	ND	5.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9500122	1/20/95
	ND	5.0 µg/L	9501862	6/2/95
Chlorobenzene	ND	2.0 µg/L	9203339	11/30/92
	ND	0.003 mg/L	9100991	5/29/91
	ND	0.02 mg/L	9101832	9/17/91
	ND	0.02 mg/L	9200469	2/24/92
	ND	0.02 mg/L	9201082	4/29/92
	ND	2.0 µg/L	9203270	11/17/92
	ND	5.0 µg/L	9402149	7/14/94
	ND	5.0 µg/L	9403244	10/24/94

continued on next page

Table A-4. (continued)

Compound	Extraction concentration	Limit of detection	Sample ID number	Sample date
Chlorobenzene (continued)	ND	5.0 µg/L	9500122	1/20/95
	ND	5.0 µg/L	9501862	6/2/95
Chloroform	ND	2.0 µg/L	9203339	11/30/92
	ND	0.003 mg/L	9100991	5/29/91
	ND	0.02 mg/L	9101832	9/17/91
	ND	0.02 mg/L	9200469	2/24/92
	ND	0.02 mg/L	9201082	4/29/92
	ND	3.0 µg/L	9203270	11/17/92
	ND	3.0 µg/L	9203339	11/30/92
	ND	5.0 µg/L	9402149	7/14/94
	ND	5.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9500122	1/20/95
	ND	8.0 µg/L	9501862	6/2/95
	ND	5.0 µg/L	9501862	6/2/95
1,2-dichloroethane	ND	0.003 mg/L	9100991	5/29/91
	ND	0.02 mg/L	9200469	2/24/92
	ND	0.02 mg/L	9201082	4/29/92
	ND	8.0 µg/L	9203270	11/17/92
	ND	8.0 µg/L	9203339	11/30/92
	ND	5.0 µg/L	9402149	7/14/94
	ND	5.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9500122	1/20/95
	ND	5.0 µg/L	9501862	6/2/95
1,1-dichloroethylene	ND	0.003 mg/L	9100991	5/29/91
[1,1 dichloroethene]	ND	0.02 mg/L	9200469	2/24/92
[Vinylidene chloride]	ND	0.02 mg/L	9201082	4/29/92
	ND	3.0 µg/L	9203270	11/17/92
	ND	3.0 µg/L	9203339	11/30/92
	ND	5.0 µg/L	9402149	7/14/94
	ND	5.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9500122	1/20/95
	ND	5.0 µg/L	9501862	6/2/95
Ethyl acetate	ND	0.02 mg/L	9100991	5/29/91
	ND	0.1 mg/L	9101832	9/17/91
	ND	50.0 µg/L	9203270	11/17/92
	ND	50.0 µg/L	9203339	11/30/92
Ethyl benzene	ND	0.02 mg/L	9100991	5/29/91

continued on next page

Table A-4. (continued)

Compound	Extraction concentration	Limit of detection	Sample ID number	Sample date
Ethyl benzene (continued)	ND	0.02 mg/L	9101832	9/17/91
	ND	2.0 µg/L	9203270	11/17/92
	ND	2.0 µg/L	9203339	11/30/92
	ND	5.0 µg/L	9402149	7/14/94
	ND	5.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9501862	6/2/95
Freon 113	ND	0.02 mg/L	9100991	5/29/91
[chlorotrifluoromethane]	0.03 mg/L	0.02 mg/L	9101832	9/17/91
	ND	3.0 µg/L	9203270	11/17/92
	ND	3.0 µg/L	9203339	11/30/92
Methylene chloride	ND	0.05 mg/L	9100991	5/29/91
[dichloromethane]	ND	0.05 mg/L	9101832	9/17/91
	ND	3.0 µg/L	9203270	11/17/92
	ND	3.0 µg/L	9203339	11/30/92
	80.0 µg/L[a]	5.0 µg/L	9402149	7/14/94
	7.0 µg/L[a]	5.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9500122	1/20/95
	ND	3.0 µg/L	9501862	6/2/95
Methyl ethyl ketone	ND	0.02 mg/L	9100991	5/29/91
[2-butanone]	ND	0.02 mg/L	9101832	9/17/91
	ND	0.1 mg/L	9200469	2/24/92
	ND	0.1 mg/L	9201082	4/29/92
	ND	50.0 µg/L	9203270	11/17/92
	ND	50.0 µg/L	9203339	11/30/92
	ND	100.0 µg/L	9402149	7/14/94
	ND	100.0 µg/L	9403244	10/24/94
	33.0 µg/L	10.0 µg/L	9500122	1/20/95
	ND	100.0 µg/L	9501862	6/2/95
Methyl isobutyl ketone	ND	0.1 mg/L	9100991	5/29/91
[4-methyl-2pentanone]	ND	0.1 mg/L	9101832	9/17/91
	ND	50.0 µg/L	9203270	11/17/92
	ND	50.0 µg/L	9203339	11/30/92
	ND	50.0 µg/L	9402149	7/14/94
	ND	50.0 µg/L	9403244	10/24/94
	ND	50.0 µg/L	9501862	6/2/95
Tetrachloroethylene	ND	0.004 mg/L	9100991	5/29/91
[tetrachloroethene]	ND	0.02 mg/L	9200469	2/24/92

continued on next page

Table A-4. (continued)

Compound	Extraction concentration	Limit of detection	Sample ID number	Sample date
Tetrachloroethylene [tetrachloroethene] (continued)	ND	0.02 mg/L	9201082	4/29/92
	ND	10.0 µg/L	9203270	11/17/92
	ND	10.0 µg/L	9203339	11/30/92
	ND	5.0 µg/L	9402149	7/14/94
	1.0 µg/L[b]	5.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9500122	1/20/95
	ND	5.0 µg/L	9501862	6/2/95
Toluene	ND	0.02 mg/L	9100991	5/29/91
	ND	0.02 mg/L	9101832	9/17/91
	ND	2.0 µg/L	9203270	11/17/92
	2.0 µg/L	2.0 µg/L	9203339	11/30/92
	ND	5.0 µg/L	9402149	7/14/94
	30.0 µg/L	5.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9501862	6/2/95
Trichloroethylene [trichloroethene]	ND	0.003 mg/L	9100991	5/29/91
	ND	0.02 mg/L	9200469	2/24/92
	ND	0.02 mg/L	9201082	4/29/92
	ND	3.0 µg/L	9203270	11/17/92
	ND	3.0 µg/L	9203339	11/30/92
	ND	5.0 µg/L	9402149	7/14/94
	3.0 µg/L	5.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9500122	1/20/95
	ND	5.0 µg/L	9501862	6/2/95
Vinyl chloride	ND	0.02 mg/L	9100991	5/29/91
	ND	0.02 mg/L	9200469	2/24/92
	ND	0.02 mg/L	9201082	4/29/92
	ND	3.0 µg/L	9203270	11/17/92
	ND	3.0 µg/L	9203339	11/30/92
	ND	10.0 µg/L	9402149	7/14/94
	ND	10.0 µg/L	9403244	10/24/94
	ND	5.0 µg/L	9500122	1/20/95
	ND	10.0 µg/L	9501862	6/2/95

[a] indicates analyte found is blank as well as sample.

[b] is estimated value.

ND = Not detected at or above limit of detection. See detailed Analysis Data Sheets in Appendix B for other volatile organics, not detected in 7/94, 10/94, and 1/95 results. TCLP analytical procedures using U.S. Environmental Protection Agency (EPA) preparation methods 1311/5030 and EPA analytical methods 8240, 8260, and/or 8270.

H 01 052 681365

[illegible] NATIONAL LABORATORY Received by HWM RECEIVED 561610

HAZARDOUS WASTE DISPOSAL REQUISITION

OCT 11 1989 SEP 19 1989 551518

Program: MFD
Bldg. 829
Account No.: 3932.~~84~~ 92
Waste Form: DRY SOLIDS ☑ LIQUID ☐ SLUDGE ☐ POWDER ☐ GAS ☐ PRESSURIZED LIQUID ☐ OTHER ☐
Container: DRUM ☑ CARBOY ☐ CAN ☐ 7A BOX ☐ TANK ☐
Other Container:
Waste Stream: Used for H.E. Processing
Hazards: FLAMMABLE ☐ EXPLOSIVE ☐ ORGANIC ☑ TOXIC ☑
Other Hazards:
Analysis Sample No.: 8900896
HWM Pick Up Date: 10/19/89

HWM USE ONLY 883 ab

ITEM	CHEMICAL/PHYSICAL DESCRIPTION	WEIGHT Quantity	WEIGHT Units	Dot#	HAZARD CLASS	PRE CUR	EPA#	DOHS#	TREATMENT No.	TREATMENT Date	TREATMENT By	LOCATION	DRUM #	DISPOSITION
1	ANTIMONY	mg/L	2.2	NA 9189	ORM-E	N	—	181	S01	10/19/89	VE	883	✓	
2	Arsenic		0.9											
3	Barium		15											
4	Beryllium		<0.05											
5	Cadmium		0.86											
6	~~Chromium VI~~		NA											
7	Chromium		0.8						S01	3/13/90	B.T.	612E ~~612RO~~	/	4054474
8	Cobalt		0.7											
9	Copper		7.2											
10	Lead		5.1											
11	Mercury		<0.01											
12	Molybdenum		1.1											
13	Nickel		1.0											
14	Selenium		0.18											
15	Silver		<0.1											
16	Thallium		<0.1											
17	Vanadium		0.7											
18	Zinc		120											
1	55 Drum of Ash from Burn Pit	250#												

A-14

DELETED Carol 4/5

USE CONTINUATION FORM FOR ADDITIONAL ITEMS

Originator Name (Print): M. Satterfield
L-Code: B10
Ext.: 35246
Hazards Control Name (Print): Victor Elliott

UPDATED

DISTRIBUTION: WHITE - Hazardous Waste Management

EXTRACTION PROCEDURE TOXICITY TEST
(EP TOXICITY)
METALS

Sample I.D.: 89-00-896

Sample Received: 08/14/89

Sample Analyzed: See below

Sample Matrix: WASTE

Client: LLNL

Client Ref. No.: 5520400

Lab Client Code: 76419

Lab No.: 8908164-09A

Date	Method No.	Analyte	Extract Concentration mg/L	Maximum Concentration Limit mg/L	Limit c Detecti mg/I
08/23/89	6010	Arsenic	<0.1	5.0	0.1
08/23/89	6010	Barium	<0.1	100.0	0.1
08/23/89	6010	Cadmium	<0.05	1.0	0.05
08/23/89	6010	Chromium	<0.1	5.0	0.1
08/23/89	6010	Lead	<0.1	5.0	0.1
08/22/89	7471	Mercury	<0.01	0.2	0.01
08/23/89	6010	Selenium	<0.1	1.0	0.1
08/23/89	6010	Silver	<0.1	5.0	0.1

Method Reference: EPA 1310, SW-846, 2nd Edition

< = less than, below limit of detection

SOLUBLE THRESHOLD LIMIT CONCENTRATION ANALYSIS
(STLC)
METALS

Sample I.D.: 89-00-896

Sample Received: 08/14/89

Sample Analyzed: See below

Sample Matrix: WASTE

Client: LLNL

Client Ref. No.: 5520400

Lab Client Code: 76419

Lab No.: 8908164-09A

Date Analyzed	Method No.	Analyte	Extract Concentration mg/L	STLC* mg/L	Limit of Detection mg/L
08/21/89	6010	Antimony	2.2	15	0.1
08/21/89	6010	Arsenic	0.9	5.0	0.1
08/21/89	6010	Barium	15	100	0.1
08/21/89	6010	Beryllium	<0.05	0.75	0.05
08/21/89	6010	Cadmium	0.86	1.0	0.05
NA	7196	Chromium VI	NA	5	0.1
08/21/89	6010	Chromium	0.9	560	0.1
08/21/89	6010	Cobalt	0.7	80	0.1
08/21/89	6010	Copper	7.2	25	0.1
08/21/89	6010	Lead	5.1	5.0	0.1
08/22/89	7470	Mercury	<0.01	0.2	0.01
08/21/89	6010	Molybdenum	1.1	350	0.1
08/21/89	6010	Nickel	1.0	20	0.1
08/21/89	6010	Selenium	0.18	1.0	0.05
08/21/89	6010	Silver	<0.1	5	0.1
08/21/89	6010	Thallium	<0.1	7.0	0.1
08/21/89	6010	Vanadium	0.7	24	0.1
08/21/89	6010	Zinc	120	250	0.1

*STLC = Soluble Threshold Limit Concentration, 22CAC66693 (CA Title 22).
Sample prepared by Waste Extraction Test, 22CAC66700 (CA Title 22).

< = less than, below limit of detection

NA = Not Analyzed

LAWRENCE LIVERMORE NATIONAL LABORATORY
HAZARDOUS WASTE MANAGEMENT CONTROL LABORATORY
ANALYSIS REQUEST

To be filled out by the person submitting the sample

SAMPLE NUMBER 1–7	ANALYSIS 8–22	BLDG. 23–26	ROOM 27–31	LOCATION (ID) 32–35	DATE TAKEN 36–40	LAB BOOK REFERENCE 41–45	METHD 46–48	RESULTS 49–54	UNITS 55–60	DATE COMPLETED 61–65
8906896	CD	829	Burn PiT	1	19989					
	Cr									
	NI									
	Cu									
	Zn									
	As									
	BE									
	Pb									
	EP-TOX METALS									
	CAM WET									

A17

SAMPLE NOTES: Ash Sample Taken From Burn pit 1 Located at B-829

COMMENTS: please send Results To Victor Elliott L-874

Victor Elliott 35509

Sample collected by/Date Phone

Analyst/Date

David Silbern 8/31/89 8/31/89

Supervisor/Date Date Reported

LL 6267

LAWRENCE LIVERMORE NATIONAL LABORATORY
HAZARDOUS WASTE MANAGEMENT CONTROL LABORATORY
ANALYSIS REQUEST

To be filled out by the person submitting the sample

SAMPLE NUMBER	ANALYSIS	BLDG.	ROOM	LOCATION (ID)	DATE TAKEN	LAB BOOK REFERENCE	METHD	RESULTS	UNITS	DATE COMPLETED
1 2 3 4 5 6 7	8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	23 24 25 26	27 28 29 30 31	32 33 34 35	36 37 38 39 40	41 42 43 44 45	46 47 48	49 50 51 52 53 54	55 56 57 58 59 60	61 62 63 64 65
9001800	AcETone	829			82290					
	methlyeneCHloride									
	EthylAcetATe									
	Freon TF									
	MEK									
	methylIsobutyl Ketone									
	Toluene									
	CD									
	Cr									
	Cu									
	ni									
	Zn									
	Ag									
	BE									
	Pb									

SAMPLE NOTES: Burn Ash.

COMMENTS: Send copy to Vic Elliott L-874

VR Elliott 8/22/90 35309
Sample collected by/Date Phone

WB 9/16/90
Analyst/Date

9/28/90
Supervisor/Date

9/28/90
Date Reported

LL 6267

EPA METHOD 8240
PURGEABLE ORGANICS
(LOW LEVEL METHOD)

(CONTINUED)

Sample I.D.: 9001800

Sample Received: 08/23/90

Sample Analyzed: 08/28/90

Sample Matrix: ASH

Client: LLNL

Client Ref. No.: DS35

Lab Client Code: 76419

Lab No.: 9008186-17A

Compound	CAS #	Concentration ug/kg	Limit of Detection ug/kg
Toluene	108-88-3	3	2
Chlorobenzene	108-90-7	ND	3
Ethylbenzene	100-41-4	ND	3
1,3-Dichlorobenzene	541-73-7	ND	3
,2-Dichlorobenzene	95-50-1	ND	3
1,4-Dichlorobenzene	106-46-7	ND	3
Freon 113	76-13-1	ND	3
Total Xylenes	1330-20-7	ND	3
Acetone	67-64-1	ND	20
2-Butanone	78-93-3	ND	20
4-Methyl-2-pentanone	108-10-1	ND	20
2-Hexanone	591-78-6	ND	20
Vinyl acetate	108-05-4	ND	10
Carbon disulfide	75-15-0	ND	3
Styrene	100-42-5	ND	3
Acrolein	107-02-8	ND	10
Acrylonitrile	107-13-1	ND	10

ND = Not detected at or above limit of detection

TOTAL THRESHOLD LIMIT CONCENTRATION ANALYSIS
(TTLC)
METALS

Sample I.D.: 9001800

Client: LLNL

Sample Received: 08/30/90

Client Ref. No.: 5250400

Sample Analyzed: See below

Lab Client Code: 76419

Sample Matrix: ACID_DIGEST

Lab No.: 9008248-19A

Date Analyzed	Method No.	Analyte	Sample Concentration mg/L	STLC* mg/L	TTLC** mg/L	Limit of Detection mg/L
09/04/90	6010	Antimony	<0.05	15	500	0.05
	7060	Arsenic	--	5.0	500	0.005
09/04/90	6010	Barium	2.0	100	10,000	0.05
09/04/90	6010	Beryllium	0.005	0.75	75	0.005
09/04/90	6010	Cadmium	0.18	1.0	100	0.005
--	7196	Chromium VI	--	5	500	0.05
09/04/90	6010	Chromium	1.9	560	2,500	0.05
09/04/90	6010	Cobalt	22	80	8,000	0.05
09/04/90	6010	Copper	9.5	25	2,500	0.05
09/04/90	6010	Lead	4.9	5.0	1,000	0.05
	7470	Mercury	--	0.2	20	0.01
09/04/90	6010	Molybdenum	<0.05	350	3,500	0.05
09/04/90	6010	Nickel	1.1	20	2,000	0.05
	7740	Selenium	--	1.0	100	0.005
09/04/90	6010	Silver	0.24	5	500	0.05
09/04/90	6010	Thallium	<0.05	7.0	700	0.05
09/04/90	6010	Vanadium	0.69	24	2,400	0.05
09/04/90	6010	Zinc	27	250	5,000	0.05

* STLC = Soluble Threshold Limit Concentration, 22CAC66693 (CA Title 22).
**TTLC = Total Threshold Limit Concentration, 22CAC66693 (CA Title 22), reported on wet weight basis.

< = less than, below limit of detection

-- Information not available or not applicable

EPA METHOD 8240
PURGEABLE ORGANICS
(LOW LEVEL METHOD)

Sample I.D.: 9001800

Sample Received: 08/23/90

Sample Analyzed: 08/28/90

Sample Matrix: ASH

Client: LLNL

Client Ref. No.: DS35

Lab Client Code: 76419

Lab No.: 9008186-17A

Compound	CAS #	Concentration ug/kg	Limit of Detection ug/kg
Chloromethane	74-87-3	ND	10
Bromomethane	74-83-9	ND	4
Vinyl chloride	75-01-4	ND	4
Chloroethane	75-00-3	ND	4
ethylene chloride	75-09-2	ND	10
ichlorofluoromethane	75-69-4	ND	3
,1-Dichloroethene	75-35-4	ND	3
1,1-Dichloroethane	75-35-3	ND	3
Trans-1,2-Dichloroethene	156-60-5	ND	3
Cis-1,2-Dichloroethene	156-59-2	ND	3
1,2-Dichloroethene (total)	540-59-0	ND	3
Chloroform	67-66-3	ND	3
1,2-Dichloroethane	107-06-2	ND	3
1,1,1-Trichloroethane	71-55-6	4	3
Carbon tetrachloride	56-23-5	ND	3
Bromodichloromethane	75-27-4	ND	3
1,2-Dichloropropane	78-87-5	ND	3
Cis-1,3-Dichloropropene	10061-01-5	ND	3
Trichloroethene	79-01-6	ND	4
Benzene	71-43-2	ND	2
Dibromochloromethane	124-48-1	ND	2
1,1,2-Trichloroethane	79-00-5	ND	3
Trans-1,3-Dichloropropene	10061-02-6	ND	5
2-Chloroethylvinylether	100-75-8	ND	3
Bromoform	75-25-2	ND	3
1,1,2,2-Tetrachloroethane	79-34-5	ND	4
Tetrachloroethene	127-18-4	23	4

ND = Not detected at or above limit of detection

Interdepartmental letterhead
Mail Station L- 325
Ext: 2-6479

September 16, 1990

To: Susan Gagner

From: Winifred Burks /WB rcm

Subject: **Sample analysis for Ethyl Acetate by GC/MS (Finnigan Mat. INCOS)**

Sample No.	Ethyl Acetate	Detection Limit
9001081	ND	10 ng/ul
9001435	ND	10 ng/ul
9001450	ND	10 ng/ul
9001485	ND	10 ng/ul
9001800	ND	10 ng/ul
9001801	ND	10 ng/ul

ND= Not detected

WB/rcm
EAS-12

University of California
Lawrence Livermore
National Laboratory

LAWRENCE LIVERMORE NATIONAL LABORATORY
HAZARDOUS WASTE MANAGEMENT CONTROL LABORATORY
ANALYSIS REQUEST

To be filled out by the person submitting the sample

SAMPLE NUMBER	ANALYSIS	BLDG.	ROOM	LOCATION (ID)	DATE TAKEN	LAB BOOK REFERENCE	METHD	RESULTS	UNITS	DATE COMPLETED
1 2 3 4 5 6 7	8 9 10 11 12 13 14 15 16 17 18 19 20 21 22	23 24 25 26	27 28 29 30 31	32 33 34 35	36 37 38 39 40	41 42 43 44 45	46 47 48	49 50 51 52 53 54	55 56 57 58 59 60	61 62 63 64 65
9001801	Acetone	829			82270					
	Ethyl Acetate									
	Freon TF									
	methlyenechlorid									
	MEK									
	methyl Isobutyl ketone									
	Toluene									
	CD									
	Cr									
	Cu									
	Ni									
	Zn									
	Ag									
	BE									
	Pb									

SAMPLE NOTES: Burn ASA

COMMENTS: Send copy to Vic Elliott L-877

VRElliott 8/22/90 35502
Sample collected by/Date
Phone

WB 9/16/90
Analyst/Date

David [illegible] 9/28/90
Supervisor/Date

9/28/90
Date Reported

LL 6267

Interdepartmental letterhead
Mail Station L- 325
Ext: 2-6479

September 16, 1990

To: Susan Gagner

From: Winifred Burks /WB rcm

Subject: **Sample analysis for Ethyl Acetate by GC/MS (Finnigan Mat. INCOS)**

Sample No.	**Ethyl Acetate**	**Detection Limit**
9001081	ND	10 ng/ul
9001435	ND	10 ng/ul
9001450	ND	10 ng/ul
9001485	ND	10 ng/ul
9001800	ND	10 ng/ul
9001801	ND	10 ng/ul

ND= Not detected

WB/rcm
EAS-12

University of California
Lawrence Livermore
National Laboratory

TOTAL THRESHOLD LIMIT CONCENTRATION ANALYSIS
(TTLC)
METALS

Sample I.D.: 9001801

Client: LLNL

Sample Received: 08/30/90

Client Ref. No.: 5250400

Sample Analyzed: See below

Lab Client Code: 76419

Sample Matrix: ACID_DIGEST

Lab No.: 9008248-20A

Date Analyzed	Method No.	Analyte	Sample Concentration mg/L	STLC* mg/L	TTLC** mg/L	Limit of Detection mg/L
09/04/90	6010	Antimony	<0.05	15	500	0.05
	7060	Arsenic	--	5.0	500	0.005
9/04/90	6010	Barium	20	100	10,000	0.05
/04/90	6010	Beryllium	0.016	0.75	75	0.005
09/04/90	6010	Cadmium	0.60	1.0	100	0.005
--	7196	Chromium VI	--	5	500	0.05
09/04/90	6010	Chromium	3.2	560	2,500	0.05
09/04/90	6010	Cobalt	0.57	80	8,000	0.05
09/04/90	6010	Copper	120	25	2,500	0.05
09/04/90	6010	Lead	48	5.0	1,000	0.05
	7470	Mercury	--	0.2	20	0.01
09/04/90	6010	Molybdenum	<0.05	350	3,500	0.05
09/04/90	6010	Nickel	1.1	20	2,000	0.05
	7740	Selenium	--	1.0	100	0.005
09/04/90	6010	Silver	0.09	5	500	0.05
09/04/90	6010	Thallium	<0.05	7.0	700	0.05
09/04/90	6010	Vanadium	0.77	24	2,400	0.05
09/04/90	6010	Zinc	84	250	5,000	0.05

* STLC = Soluble Threshold Limit Concentration, 22CAC66693 (CA Title 22).
**TTLC = Total Threshold Limit Concentration, 22CAC66693 (CA Title 22), reported on wet weight basis.

< = less than, below limit of detection

\- Information not available or not applicable

EPA METHOD 8240
PURGEABLE ORGANICS
(LOW LEVEL METHOD)

Sample I.D.: 9001801

Sample Received: 08/23/90

Sample Analyzed: 08/27/90

Sample Matrix: ASH

Client: LLNL

Client Ref. No.: D535

Lab Client Code: 76419

Lab No.: 9008186-18A

Compound	CAS #	Concentration ug/kg	Limit of Detection ug/kg
Chloromethane	74-87-3	ND	50
Bromomethane	74-83-9	ND	20
Vinyl chloride	75-01-4	ND	20
Chloroethane	75-00-3	ND	20
Methylene chloride	75-09-2	ND	50
Trichlorofluoromethane	75-69-4	ND	20
1,1-Dichloroethene	75-35-4	ND	20
1,1-Dichloroethane	75-35-3	ND	20
Trans-1,2-Dichloroethene	156-60-5	ND	20
Cis-1,2-Dichloroethene	156-59-2	ND	20
1,2-Dichloroethene (total)	540-59-0	ND	20
Chloroform	67-66-3	ND	20
1,2-Dichloroethane	107-06-2	ND	20
1,1,1-Trichloroethane	71-55-6	1,000	20
Carbon tetrachloride	56-23-5	ND	20
Bromodichloromethane	75-27-4	ND	20
1,2-Dichloropropane	78-87-5	ND	20
Cis-1,3-Dichloropropene	10061-01-5	ND	20
Trichloroethene	79-01-6	ND	20
Benzene	71-43-2	40	10
Dibromochloromethane	124-48-1	ND	10
1,1,2-Trichloroethane	79-00-5	ND	20
Trans-1,3-Dichloropropene	10061-02-6	ND	30
2-Chloroethylvinylether	100-75-8	ND	20
Bromoform	75-25-2	ND	20
1,1,2,2-Tetrachloroethane	79-34-5	ND	20
Tetrachloroethene	127-18-4	780	20

ND = Not detected at or above limit of detection

EPA METHOD 8240
PURGEABLE ORGANICS
(LOW LEVEL METHOD)

(CONTINUED)

Sample I.D.: 9001801	Client: LLNL
Sample Received: 08/23/90	Client Ref. No.: DS35
Sample Analyzed: 08/27/90	Lab Client Code: 76419
Sample Matrix: ASH	Lab No.: 9008186-18A

Compound	CAS #	Concentration ug/kg	Limit of Detection ug/kg
Toluene	108-88-3	130	10
Chlorobenzene	108-90-7	ND	20
Ethylbenzene	100-41-4	30	20
3-Dichlorobenzene	541-73-7	ND	20
2-Dichlorobenzene	95-50-1	ND	20
1,4-Dichlorobenzene	106-46-7	ND	20
Freon 113	76-13-1	ND	20
Total Xylenes	1330-20-7	ND	20
Acetone	67-64-1	ND	100
2-Butanone	78-93-3	ND	100
4-Methyl-2-pentanone	108-10-1	ND	100
2-Hexanone	591-78-6	ND	100
Vinyl acetate	108-05-4	ND	50
Carbon disulfide	75-15-0	ND	20
Styrene	100-42-5	ND	20
Acrolein	107-02-8	ND	50
Acrylonitrile	107-13-1	ND	50

ND = Not detected at or above limit of detection

Appendix B

Borehole and Monitor Well Logs

The borehole and monitor well logs listed below are on the pages that follow:

B-829-01

B-829-02

B-829-03

B-829-04

B-829-05

W-829-06

B-829-07

W-829-08

B-829-09

B-829-10

B-829-11

B-829-12

B-829-13

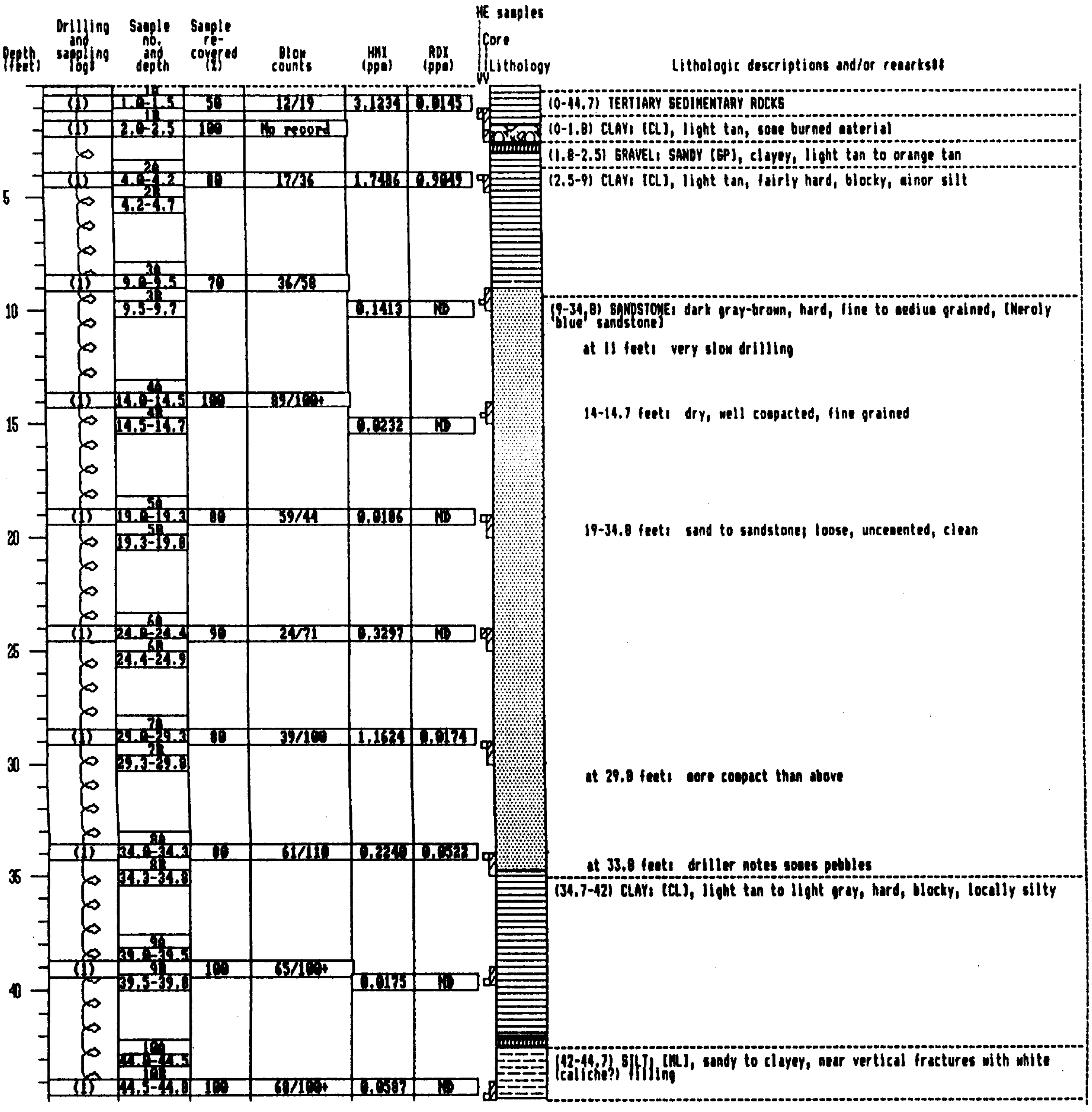
B-829-14

B-829-15

W-827-04 (composite log)

W-827-05 (composite log)

LOG: EXPLORATORY HOLE 829-1



Drilling and sampling log#	Sample no. and depth	Sample re-covered (%)	Blow counts	HMX (ppm)	RDX (ppm)
(1)	1A 1.0-1.5	50	12/19	3.1234	0.0145
(1)	1B 2.0-2.5	100	No record		
(1)	2A 4.0-4.2	80	17/36	1.7486	0.9049
	2B 4.2-4.7				
(1)	3A 9.0-9.5	70	36/58		
	3B 9.5-9.7			0.1413	ND
(1)	4A 14.0-14.5	100	89/100+		
	4B 14.5-14.7			0.0232	ND
(1)	5A 19.0-19.3	80	59/44	0.0186	ND
	5B 19.3-19.8				
(1)	6A 24.0-24.4	90	24/71	0.3297	ND
	6B 24.4-24.9				
(1)	7A 29.0-29.3	80	39/100	1.1624	0.0174
	7B 29.3-29.8				
(1)	8A 34.0-34.3	80	61/110	0.2240	0.0522
	8B 34.3-34.8				
	9A 39.0-39.5				
(1)	9B	100	65/100+		
	39.5-39.8			0.0175	ND
	10A 44.0-44.5				
(1)	10B 44.5-44.8	100	68/100+	0.0587	ND

Lithologic descriptions and/or remarks##

(0-44.7) TERTIARY SEDIMENTARY ROCKS

(0-1.8) CLAY: [CL], light tan, some burned material

(1.8-2.5) GRAVEL: SANDY [GP], clayey, light tan to orange tan

(2.5-9) CLAY: [CL], light tan, fairly hard, blocky, minor silt

(9-34.8) SANDSTONE: dark gray-brown, hard, fine to medium grained, [Neroly 'blue' sandstone]

at 11 feet: very slow drilling

14-14.7 feet: dry, well compacted, fine grained

19-34.8 feet: sand to sandstone; loose, uncemented, clean

at 29.8 feet: more compact than above

at 33.8 feet: driller notes somes pebbles

(34.7-42) CLAY: [CL], light tan to light gray, hard, blocky, locally silty

(42-44.7) SILT: [ML], sandy to clayey, near vertical fractures with white (caliche?) filling

EXPLORATORY HOLE 829-1

Geologic Logging:
N. Crow, LLNL

Hole Location:
In middle of burn pit 2, near B-829,
Site 300

Coordinates:
N: 417,309.7
E: 1,703,087.1

Ground Elevation: 1075.65 feet

Geophysical Logging: None

Drilling:
D. Wagster, P. C. Exploration Inc.,
Roseville, CA

Dates Drilled: 11/16-17/86

Drilling Method:
6-inch hollow stem auger 0-44 feet

Key: Drilling and Sampling Log

	6-inch hollow stem auger
(1)	1-1/2-inch diameter sample taken with 2-inch O.D. split tube sampler driven by 140-lb. weight falling 30 inches. Samples encased in stainless steel sleeves, sealed with aluminum foil, and inert duct tape.

ND None detected above detection limit. Detection limits vary with the amount of sample tested. Range of detection limits for this hole:

HMX = <0.0004 ppm
RDX = <0.0004 - <0.0011 ppm
TNT = 0.001 ppm (not shown on log)
VOCs = <0.2 - <2 ppm

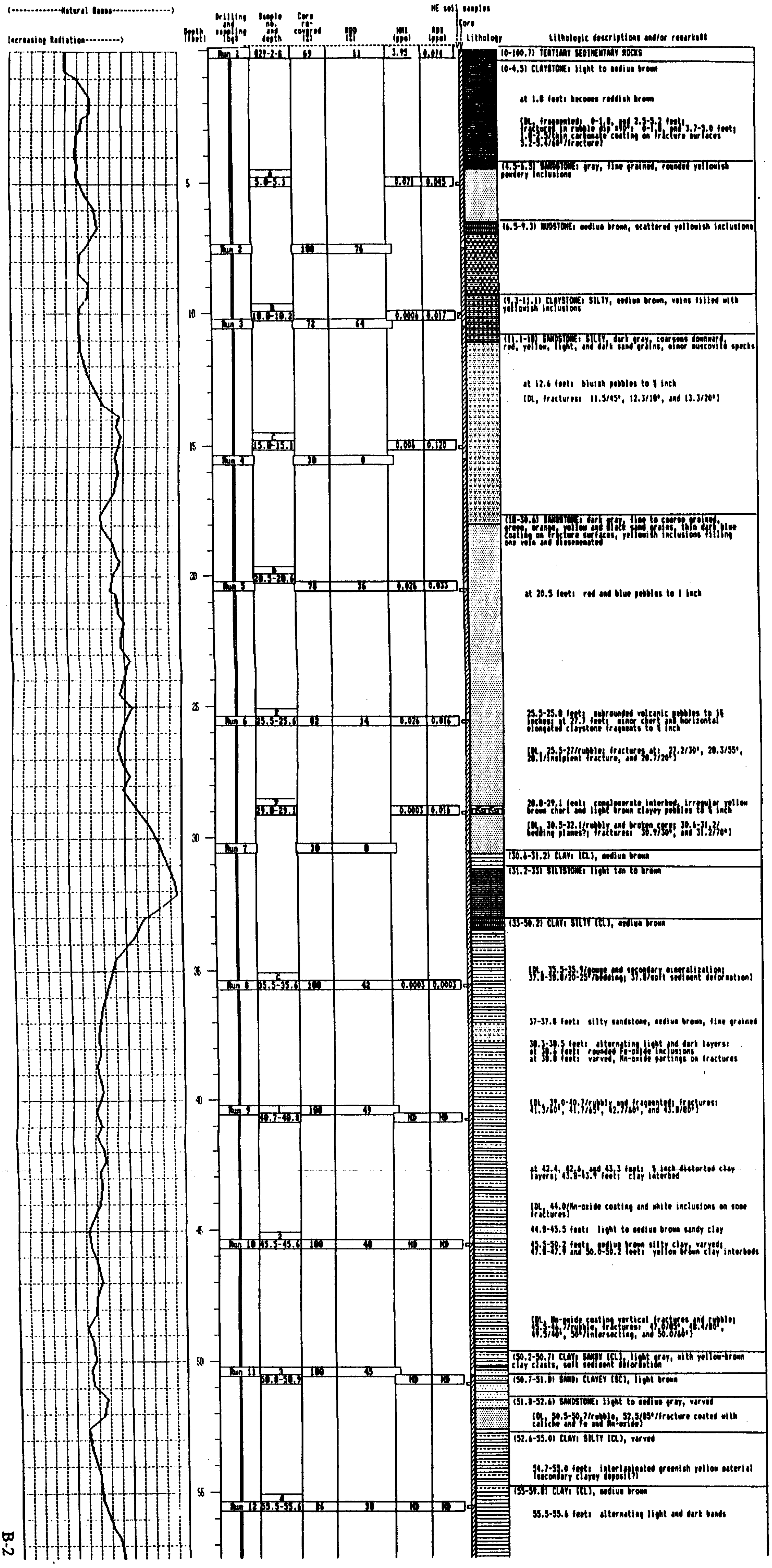
No VOCs were identified.

Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates.

Ground Water: Not encountered

Hole Completion: Backfilled with grout

LOG: EXPLORATORY HOLE 829-2



Drilling and sampling log*	Sample no. and depth	Core recovered (%)	RQD (%)	HMX (ppm)	RDX (ppm)
Run 1	829-2-0	69	11	3.95	0.074
	A 5.0-5.1			0.071	0.045
Run 2		100	76		
	B 10.0-10.2			0.0006	0.017
Run 3		72	64		
	C 15.0-15.1			0.006	0.120
Run 4		30	0		
Run 5	D 20.5-20.6	78	36	0.026	0.033
Run 6	E 25.5-25.6	82	14	0.026	0.016
	F 29.0-29.1			0.0003	0.018
Run 7		30	0		
Run 8	G 35.5-35.6	100	42	0.0003	0.0003
Run 9	1 40.7-40.8	100	49	ND	ND
Run 10	2 45.5-45.6	100	40	ND	ND
Run 11	3 50.8-50.9	100	45	ND	ND
Run 12	4 55.5-55.6	86	38	ND	ND

Lithologic descriptions and/or remarks**

(0-100.7) TERTIARY SEDIMENTARY ROCKS

(0-4.5) CLAYSTONE: light to medium brown

at 1.0 feet: becomes reddish brown

[DL, fragmented: 0-1.0, and 2.5-5.2 feet; fractured in rubble dip ≤90°: 0-1.0, and 3.7-5.0 feet; 1.0-2.5/thin carbonate coating on fracture surfaces 5.2-5.4/60°/fracture]

(4.5-6.5) SANDSTONE: gray, fine grained, rounded yellowish powdery inclusions

(6.5-9.3) MUDSTONE: medium brown, scattered yellowish inclusions

(9.3-11.1) CLAYSTONE: SILTY, medium brown, veins filled with yellowish inclusions

(11.1-18) SANDSTONE: SILTY, dark gray, coarsens downward, red, yellow, light, and dark sand grains, minor muscovite specks

at 12.6 feet: bluish pebbles to ½ inch

[DL, fractures: 11.5/45°, 12.3/10°, and 13.3/20°]

(18-30.6) SANDSTONE: dark gray, fine to coarse grained, green, orange, yellow and black sand grains, thin dark blue coating on fracture surfaces, yellowish inclusions filling one vein and disseminated

at 20.5 feet: red and blue pebbles to 1 inch

25.5-25.8 feet: subrounded volcanic pebbles to 1½ inches; at 27.3 feet: minor chert and horizontal elongated claystone fragments to ¼ inch

[DL, 25.5-27/rubble; fractures at: 27.2/30°, 28.3/55°, 28.1/insipient fracture, and 28.7/20°]

28.8-29.1 feet: conglomerate interbed, irregular yellow brown chert and light brown clayey pebbles to ¼ inch

[DL, 30.5-32.1/rubbly and broken core; 30.6-31.2/ bedding planes?; fractures: 30.9/30°, and 31.2/70°]

(30.6-31.2) CLAY: (CL), medium brown

(31.2-33) SILTSTONE: light tan to brown

(33-50.2) CLAY: SILTY (CL), medium brown

[DL, 35.5-35.9/gouge and secondary mineralization; 37.8-38.8/20-25°/bedding; 37.8/soft sediment deformation]

37-37.8 feet: silty sandstone, medium brown, fine grained

38.3-38.5 feet: alternating light and dark layers:
at 38.6 feet: rounded Fe-oxide inclusions
at 38.8 feet: varved, Mn-oxide partings on fractures

[DL, 39.0-40.7/rubbly and fragmented; fractures: 41.3/60°, 41.7/65°, 42.7/60°, and 43.8/80°]

at 42.4, 42.6, and 43.3 feet: ¼ inch distorted clay layers; 43.8-43.9 feet: clay interbed

[DL, 44.0/Mn-oxide coating and white inclusions on some fractures]

44.8-45.5 feet: light to medium brown sandy clay

45.5-50.2 feet: medium brown silty clay, varved; 47.8-47.9 and 50.0-50.2 feet: yellow brown clay interbeds

[DL, Mn-oxide coating vertical fractures and rubble; 45.5-46.7/rubble, fractures: 47.0/85°, 48.4/80°, 49.5/40°, 50°/intersecting, and 50.0/60°]

(50.2-50.7) CLAY: SANDY (CL), light gray, with yellow-brown clay clasts, soft sediment deformation

(50.7-51.8) SAND: CLAYEY (SC), light brown

(51.8-52.6) SANDSTONE: light to medium gray, varved

[DL, 50.5-50.7/rubble, 52.5/85°/fracture coated with caliche and Fe and Mn-oxide]

(52.6-55.0) CLAY: SILTY (CL), varved

54.7-55.0 feet: interlaminated greenish yellow material (secondary clayey deposit?)

(55-59.8) CLAY: (CL), medium brown

55.5-55.6 feet: alternating light and dark bands

EXPLORATORY HOLE 829-2

Geologic Logging:
P. Webster-Scholten, LLNL

Hole Location:
In middle of burn pit,
slightly west of 829-1 near B-829

Coordinates:
N: 417,306.7
E: 1,703,088.9

Ground Elevation: 1073.64 feet

Geophysical Logging:
Geo-Hydro Data Inc., Tehachapi, CA

Drilling:
D. Wagster, P. C. Exploration Inc.,
Roseville, CA

Dates Drilled: 12/2 to 12/4/86

Drilling Method:
4¾-inch air/mist rotary 0-101.5 feet

* Key: Drilling and Sampling Log

Run # Core obtained using Christensen HQ (92 mm) Wireline Punch Core System. Samples taken from core, placed in glass jar, and sealed with inert duct tape.

ND None detected above detection limit. Detection limits vary with the amount of sample tested. Range of detection limits for this hole:

HMX = <0.0003 - 0.0008 ppm
RDX = <0.0003 - 0.0008 ppm
TNT = 0.0003 - 0.0008 ppm (not shown on log)

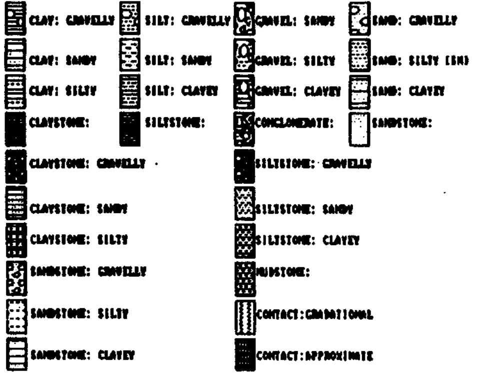
? Qualified Results: The UV spectrum in the HPLC analysis does not support the presence of HMX.

** Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates.

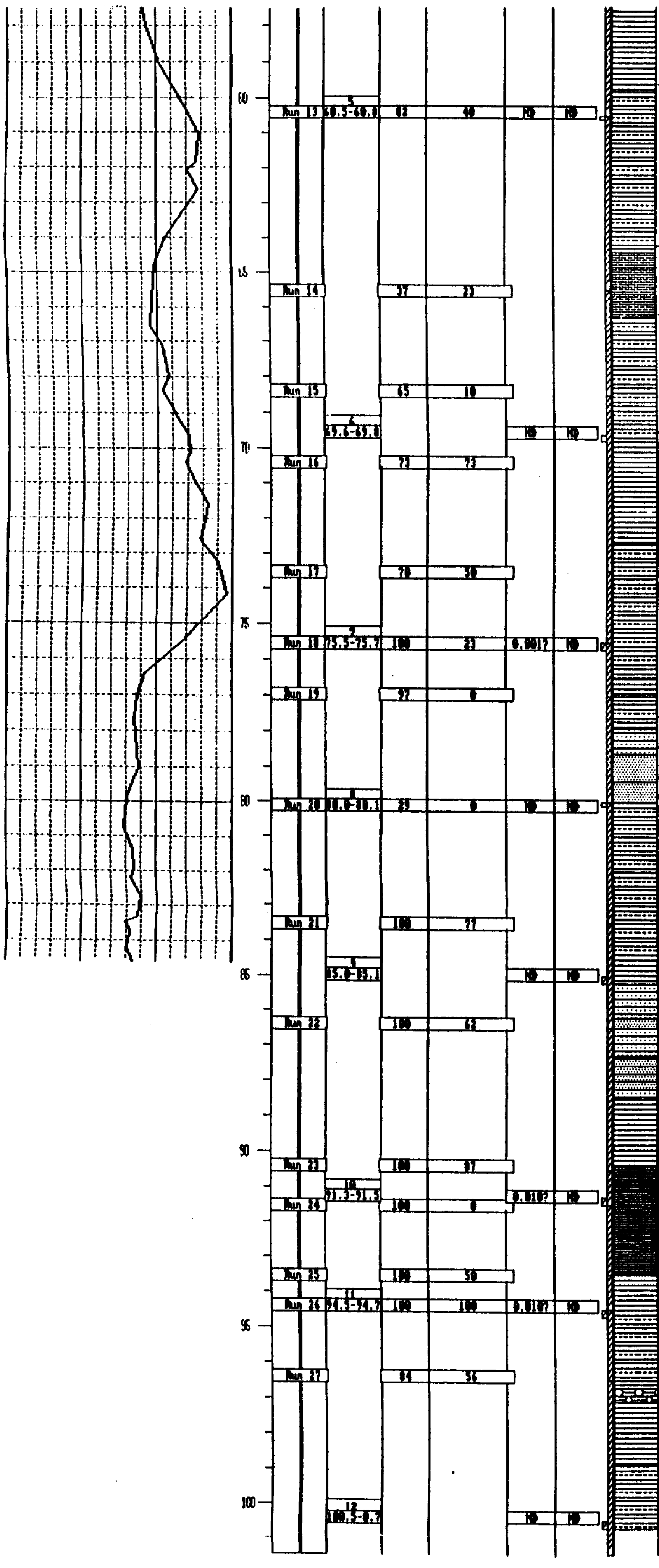
Discontinuity Log,
Notation of Bedding and Fractures:
[DL, depth(s)/dip(s)°/comment(s)]

Hole Completion: Backfilled with grout

INDEX TO LITHOLOGIC SYMBOLS



LOG: EXPLORATORY HOLE 829-2 CONTINUED



[DL, 55.5-56.5/rubbly and fragmented; fractures: 57.1/25°/Fe-oxide stained, 57.7/25°/Fe-oxide stained, 58.0/50°, 58.6/healed, 59.3/20°, and 59.4/20°/coated with Mn-oxide; 59.2-59.3/strongly weathered]

(59.8-64.4) CLAY: SILTY (CL), greenish brown, lumpy, scattered pebbles, spotted with Mn and Fe-oxide inclusions, some white inclusions

[DL, 60.9/20°/fracture; rubble: 61.9-62.2, and 64.4-64.6]

at 62.0 feet: silt increases downward, clayey pebbles to 1/8 inch; at 62.3 feet: some fine sand, fine sand increases downward

(64.4-66.3) SILTSTONE: bluish gray, minor muscovite specks, common Fe and Mn-oxide stains

(66.3-69.8) CLAY: SILTY (CL), medium brown, minor muscovite, Fe-oxide stains

[DL, fragmented: 66.3-66.7, and 68.5-68.7; 68.8/dark banding; 69.5/80°/fracture partially lined with Fe-oxide]

(69.8-72.7) CLAY: (CL), medium brown, dry, minor silt

70.9-72.7 feet: no silt

[DL, Fe-oxide lined fractures: 70.5-71.1/hackly/gouge, 71.4/80°/slickensided, and 72.7/slickensided]

(72.7-77.9) CLAY: SILTY (CL), greenish brown, mottled green, dark and yellow, dry, compact, <5% sand, some hard clayey inclusions, Fe-oxide stains throughout, whitish inclusions (caliche?)

at 76.1 feet: wet, soft; 76.1-76.9 feet: crumbly; 76.9-77.0 feet: greenish brown clay interbed; 77.0-77.9 feet: damp

[DL, fractures: 75.8-77/90°/Fe-oxide coated, 78.1/80°, and 79.4/80°; 77-80/core fragmented and broken]

(77.9-78.6) CLAY: SANDY (CL), greenish brown, fine to medium grained, becomes greener and coarser with depth

(78.6-79.4) SANDSTONE: light bluish gray, dry, hard, brittle, fine to medium grained, Fe and Mn-oxide on fractures

(79.4-80) SANDSTONE: yellow-brown, damp, dark brown clayey inclusions to 2 inches

(80-84.4) CLAY: SILTY (CL), greenish brown, difficult drilling

[DL, water (drilling fluid?) at 80 feet, water level rose 9 inches in 10 minutes; 80-81/core rubbley and broken; 80.4/±90°/fracture; 83.2/±40°/fracture; 80-84/lost air and water circulation]

(84.4-85.1) CLAY: (CL), greenish brown

(85.1-88.5) CLAY: SANDY (CL), greenish brown, slightly damp, some hard clayey inclusions

86.2-86.5 feet: light gray, dry, hard, sandstone

87.3-88.2 feet: hard clayey sandstone interbed

(88.5-90.4) CLAY: (CL), green brown, wet, very soft, locally silty and damp, some hard clayey inclusions

(90.4-93.5) CLAYSTONE: pinkish brown, dry, hard, minor silt

[DL, fractures: 92.1/65°, 92.8/0°, 92.8/40°, and 93.5/10°; 93.2/rubble; 93.5, 93.8-94.0/muddy rubble]

at 92.3 feet: becomes greenish brown, harder, and more fractured, fractures lined with Fe-oxide

(93.5-94.5?) CLAY: (CL), light greenish gray, moisture and hardness varies, no Fe-oxide stains, recovered an extra 0.8 feet of core

93.5-93.8 feet: silty clay; 93.8-94 feet: wet, very soft, minor silt, some hard clayey lumps; 94.0-94.7 feet: compact clay; 94.7-95.2 feet: broken core

(94.5-96.5) CLAY: SILTY (CL), green, clayey inclusions to ¼ inch, veins of caliche, Fe-oxide stains throughout

94.5-95.2 feet: wet, soft; 95.2-96.5 feet: damp, compact

(96.5-97.1) CLAY: GRAVELLY (CL), greenish brown to yellow-brown, hard clayey inclusions

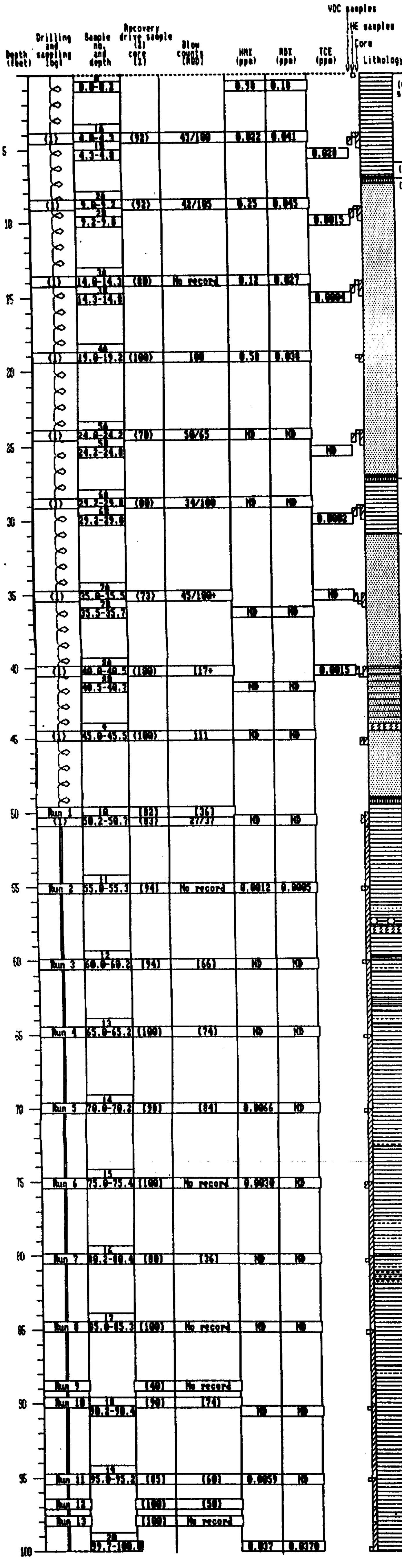
(97.1-98.9) CLAY: (CL), grades from yellow-brown to red-brown, damp, compact

(98.9-100.7) CLAY: SILTY (CL), greenish brown

[DL, 98.9/15°/fracture coated with Fe-oxide]

100.3-100.4 feet: wet, very soft, pebbley

LOG: EXPLORATORY HOLE 829-3



Drilling and sampling log	Sample no. and depth	Recovery drive sample (%) core (%)	Blow counts (RQD)	HMX (ppm)	RDX (ppm)	TCE (ppm)
	0 0.0-0.2			0.30	0.10	
(1)	1A 4.0-4.3	(92)	43/100	0.022	0.041	
	1B 4.3-4.8					0.020
(1)	2A 9.0-9.2	(92)	42/105	0.25	0.045	
	2B 9.2-9.8					0.0015
(1)	3A 14.0-14.3	(80)	No record	0.12	0.027	
	3B 14.3-14.8					0.0004
(1)	4A 19.0-19.2	(100)	100	0.50	0.030	
(1)	5A 24.0-24.2	(70)	50/65	ND	ND	
	5B 24.2-24.8					ND
(1)	6A 29.2-29.8	(80)	34/100	ND	ND	
	6B 29.2-29.8					0.0002
(1)	7A 35.0-35.5	(73)	45/100+			ND
	7B 35.5-35.7			ND	ND	
(1)	8A 40.0-40.5	(100)	117+			0.0015
	8B 40.5-40.7			ND	ND	
(1)	9 45.0-45.5	(100)	111	ND	ND	
Run 1 (1)	10 50.2-50.7	(82) (83)	[36] 27/37	ND	ND	
Run 2	11 55.0-55.3	(94)	No record	0.0012	0.0005	
Run 3	12 60.0-60.2	(94)	(66)	ND	ND	
Run 4	13 65.0-65.2	(100)	(74)	ND	ND	
Run 5	14 70.0-70.2	(90)	(84)	0.0066	ND	
Run 6	15 75.0-75.4	(100)	No record	0.0030	ND	
Run 7	16 80.2-80.4	(80)	(36)	ND	ND	
Run 8	17 85.0-85.3	(100)	No record	ND	ND	
Run 9		(40)	No record			
Run 10	18 90.2-90.4	(90)	(74)	ND	ND	
Run 11	19 95.0-95.2	(85)	(60)	0.0059	ND	
Run 12		(100)	(50)			
Run 13		(100)	No record			
	20 99.7-100.0			0.037	0.0370	

Lithologic descriptions and/or remarks**

(0-7) CLAY: [CH], light tan to medium brown very compact, slightly silty

(7-100) TERTIARY SEDIMENTARY ROCKS

(7-27) SANDSTONE: dark gray, dries blue

at 13 feet: pebbles to 1 inch

14-15 feet: dry, compact, few pebbles to 3/8 inch, white veinlets

19-19.5 feet: loose

24-24.7 feet: dry, fine to medium grained, white grains

(27-31) CLAY: [CL], slightly dark brown to light tan

(31-40) SANDSTONE: dark brown, fine to coarse grained predominately subangular fine sand, scattered pebbles to ¼ inch

at 34 feet: increasing pebbles to 10%, medium brown claystone pebbles to 1 inch

(40-44) SANDSTONE: CLAYEY, medium brown, hard angular claystone pebbles to 1 inch

41-44 feet: increasing subangular poorly sorted pebbles to 2½ inches

(44-49) SANDSTONE: medium brown, dries gray brown, minor white fine grains, minor clay, disseminated Fe-oxide

45-46.5 feet: minor pebbles; at 47 feet: 15% subangular to subrounded pebbles to 2 inches, poorly sorted

(49.5-56.1) CLAY: [CH], medium brown to pinkish brown, compact, minor disseminated Fe-oxide

50-50.1 feet: green brown clay; 50-52 feet: minor silt; 55-55.8 feet: dry, brittle; 55.8-56.1 feet: green clay

[DL, fractures: 50.4-51.3/90°/healed, 51.5-52/80°, 52-52.4/90°, and 56.8/20°; rubble: 55-55.3 and 56.1-56.7 feet]

(56.1-56.7) CLAY: SANDY [CL], crumbly, much disseminated Fe-oxide

(55.8-56.7) CLAY: GRAVELLY [CL], green, 10-15% fine to coarse sand

(57.7-77.3) CLAY: [CL], green, common green silty clay interbeds, locally disseminated with Fe-oxide
59.7-59.8 feet: dark brown fine grained sandstone; 60-60.7 feet: green silty clay interbed; 62.5-63.1 feet: light gray very hard siltstone interbed, soft reddish material to 1 inch, much Fe and Mn-oxide stains

[DL, fractures: 60.7/25°/healed, 63.1-64.2/±90°/hackly, 64.7/30°, 65/30°, 66.9/10°, 69.1/10°, and 69.2/10°; 63-63.1/contact lined with Fe and Mn-oxide]

63.4-64.3 feet: green silty clay interbeds at 64.4, 64.6 and 64.8 feet: minor silty clay lenses; 69.1-71.9 feet: hackly crumbly clay mottled green and white, increasing white inclusions with depth

71.9-72.6 feet: greenish gray silty clay; 72.6-73.8 feet: mostly green clay with minor white inclusions and irregular blotches of gray silty clay

[DL, 70-70.2/rubble; fractures: 71.5/10°, 71.9/25°, 72.1/ 0°/healed with white (chalcedony?), 72.6-72.8/50°, and 73.9/20°, 20°/intersecting; 71.9-72.6/irregular healed fracture zone; 75-77.8/±90°,/irregular fracture intersects several other fractures to develop a hackly appearence, lined with Fe and Mn-oxide stains]

(77.3-81.9) CLAY: SILTY [CL], green, disseminated Fe-oxide stains

79.3-80 feet: green clay; 81-81.6 feet: green-brown clayey siltstone; 81.6-81.9 feet: very fine grained silty sandstone; at 82.8 feet: minor lens of silt and Fe-oxide

(81.9-100) CLAY: [CL], green brown, <10% silt

[DL, 80.7-81/0°, ±90°/intersecting fractures healed with Fe-oxide; 82.1-82.5/0°/four thin planes of Fe-oxide staining (healed fractures?)]

[DL, fractures: 86.3/10°/lined with Fe-oxide, 87/30°, and 87.3-87.7/80°/slickensided and lined with Fe and Mn-oxide; 87.7-88.3/rubble zone]

87.4-88.3 feet: greenish brown silty clay, very crumbly; 88.3-89.4 and 90-91.5 feet: lumpy mottled white and green clay, minor sand

91.5-94.5 feet: harder than above, well compacted clay with green, brown, and yellow (Fe-oxide) mottling, locally pinkish brown, grades to green brown at bottom; 97.8-98 feet: soft greenish brown clay

[DL, 90-90.2/fragmented; fractures: 92.5/10° and 94/20° 95-97/hackly drilling fractures]

[DL, fractures: 97.3/10°/hackly, 97.4/20°/healed, and 98.2-98.4/0°, ?°/several intersecting fractures healed with Fe-oxide; 97.8/Fe-oxide stringers; 98-98.2/wet, soft, and fragmented core]

EXPLORATORY HOLE 829-3

Geologic Logging:
P. Webster-Scholten and
M. Crow, LLNL

Hole Location:
In middle of east burn pit, near B-829

Coordinates:
N: 417,376.4
E: 1,703,100.7

Ground Elevation: 1076.81 feet

Geophysical Logging: None

Drilling:
D. Wagster, P. C. Exploration Inc.,
Roseville, CA

Dates Drilled: 1/5 to 1/7/87

Drilling Method:
9-inch hollow stem auger 0-50 feet
4 ¾-inch air-mist rotary 50-100 feet

* Key: Drilling and Sampling Log

⌇	9-inch hollow stem auger
(1)	1⅜-inch diameter sample taken with 2-inch O.D. split tube sampler driven by 140-lb. weight falling 30 inches. Samples encased in stainless steel sleeves, sealed with aluminum foil, and inert duct tape.
Run # ┃	Core obtained using Christensen HQ (92 mm) Wireline Punch Core System. Samples taken from core, placed in glass jar, and sealed with inert duct tape.
ND	None detected above detection limit. Detection limits vary with the amount of sample tested. Range of detection limits for this hole: HMX = <0.0004 - <0.0011 ppm RDX = <0.0004 - <0.0010 ppm TNT = 0.001 ppm (not shown on log) VOCs = <0.0002 ppm
**	Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates.

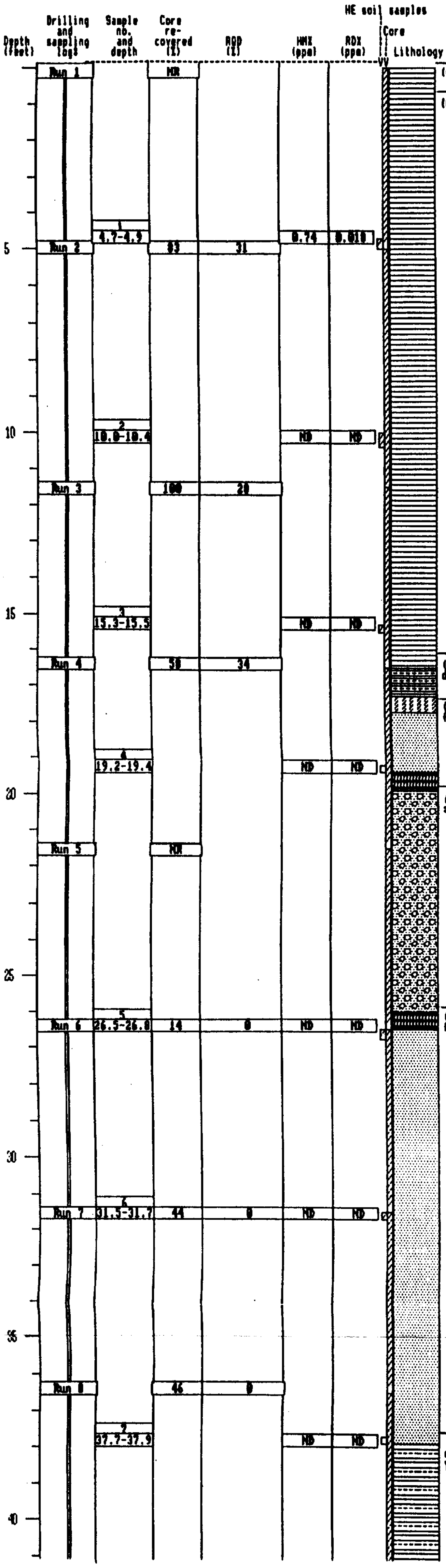
Ground Water: Not encountered

Hole Completion: Backfilled with grout

INDEX TO LITHOLOGIC SYMBOLS

▤ CLAY:	▤ SILT:	◯ GRAVEL:	▨ SAND:
▤ CLAY: GRAVELLY	▤ SILT: GRAVELLY	◯ GRAVEL: SANDY	▨ SAND: GRAVELLY
▤ CLAY: SANDY	▤ SILT: SANDY	◯ GRAVEL: SILTY	▨ SAND: SILTY [SM]
▤ CLAY: SILTY	▤ SILT: CLAYEY	◯ GRAVEL: CLAYEY	▨ SAND: CLAYEY
■ CLAYSTONE:	■ SILTSTONE:	▨ CONGLOMERATE:	▨ SANDSTONE:
■ CLAYSTONE: GRAVELLY		■ SILTSTONE: GRAVELLY	
■ CLAYSTONE: SANDY		▨ SILTSTONE: SANDY	
■ CLAYSTONE: SILTY		▨ SILTSTONE: CLAYEY	
▨ SANDSTONE: GRAVELLY		▨ MUDSTONE:	
▨ SANDSTONE: SILTY		▥ CONTACT:GRADATIONAL	
▤ SANDSTONE: CLAYEY		■ CONTACT:APPROXIMATE	

LOG: EXPLORATORY HOLE 829-4



Lithologic descriptions and/or remarks**

(0-101.5) TERTIARY SEDIMENTARY ROCKS

(0-16.5) CLAY: [CL], light to medium brown

0-5 feet: loose, no recovery; Sample 1 from cuttings

5-10.4 feet: disseminated Fe-oxide stains

[DL, 5-5.3/rubble; 6.2-8.3/rubbly and fractured; fractures: 5.1-5.5/60°, 7.6,10.0/<5°/Fe and Mn-oxide lined, 8.0-8.2/60°/clean, and 10.4/10°/Fe and Mn-oxide lined]

10.2-10.4 feet: hairline varves outlined with Mn-oxide; 11.5-16.5 feet: grades from medium brown to red-brown, dry, hard, smooth, well compacted

[DL, 11.5-13.0/rubbly and fractured; fractures: 11.5-12.3/90°/hackly, 12.2-12.4/90°, 80°/intersecting, 12.7-13.0/80°, 80°/intersecting, and 13.7/0°/conchoidal and lined with Fe and Mn-oxide]

[DL, fractures: 14.4/10°/lined with Fe-oxide and chalcedony, 14.8-15/30°, 30°/healed with chalcedony, 15.5-15.6/40°/hackly and lined with Fe and Mn-oxide; and 15.5-16.0/90°/irregular and lined with chalcedony]

(16.5-17.5) CLAYSTONE: SILTY, light brown, dry, hard, grades downward into sandstone

(17.5-19.4) SANDSTONE: dark brown, dries bluish gray, damp, fine to medium grained

[DL, 16.5-17.1/rubbly and fractured with abundant coatings of Fe-oxide and chalcedony; fractures: 17.0-17.1/30°/coated with chalcedony and Fe and Mn-oxide, and 17.7-17.9/50°/hackly; 21.5-26.5/no recovery]

(19.4-26) SANDSTONE: GRAVELLY, driller reports sandstone with ≈50% gravel

(26-37.9) SANDSTONE: dark brown, dries bluish gray, damp, fine to medium grained, disseminated Fe-oxide

[DL, fractures: 26.5-27.2/90°, 26.6/20°, 90°/intersecting, and 26.8/20°, 90°/intersecting]

at 31.5 feet: gravelly; 31.5-33.7 feet: some coarse sand

[DL, 31.5-32.3/rubble; 32.3-33.7/≈80°/hackly and irregular fracture; 32.7/20°/fracture; 36.5-41.5/Fe and Mn-oxide stained rubble]

at ≈35 feet: driller reports medium brown color (some clay?)

at ≈37.5 feet: ½ inch thick coarse grained sandstone bed; at 37.7 feet: becomes more compact

(37.9-56.5) CLAY: SILTY [CL], light to medium brown, silt content varies, Mn-oxide stained varves, interbedded yellow-brown clay and silty sandstone

EXPLORATORY HOLE 829-4

Geologic Logging:
P. Webster-Scholten, LLNL

Hole Location:
Immediately north of burner,
just southwest of Pit 2 at B-829

Coordinates:
N: 417,272.3
E: 1,703,112.3

Ground Elevation: 1080.38 feet

Geophysical Logging: None

Drilling:
D. Wagster, P. C. Exploration Inc.,
Roseville, CA

Dates Drilled: 1/9 to 1/12/87

Drilling Method:
4½-inch air/mist rotary 0-101.5 feet

* Key: Drilling and Sampling Log

Run # | Core obtained using Christensen HQ (92 mm) Wireline Punch Core System. Samples taken from core, placed in glass jar, and sealed with inert duct tape.

NR No recovery

ND None detected above detection limit. Detection limits vary with the amount of sample tested. Range of detection limits for this hole:

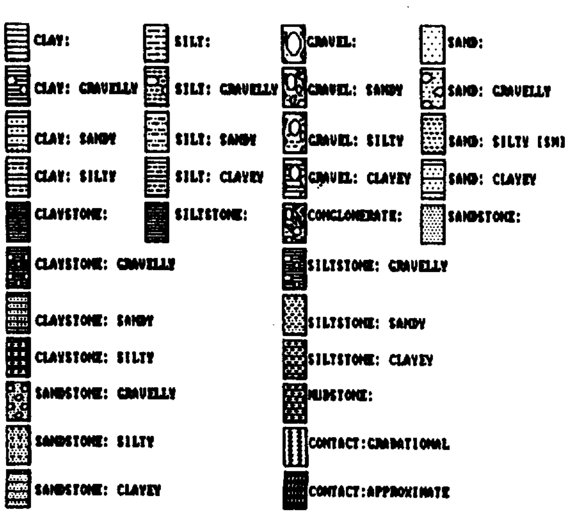
HMX = 0.0005 ppm
RDX = 0.0005 ppm
TNT = 0.0008 ppm (not shown on log)

** Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates.

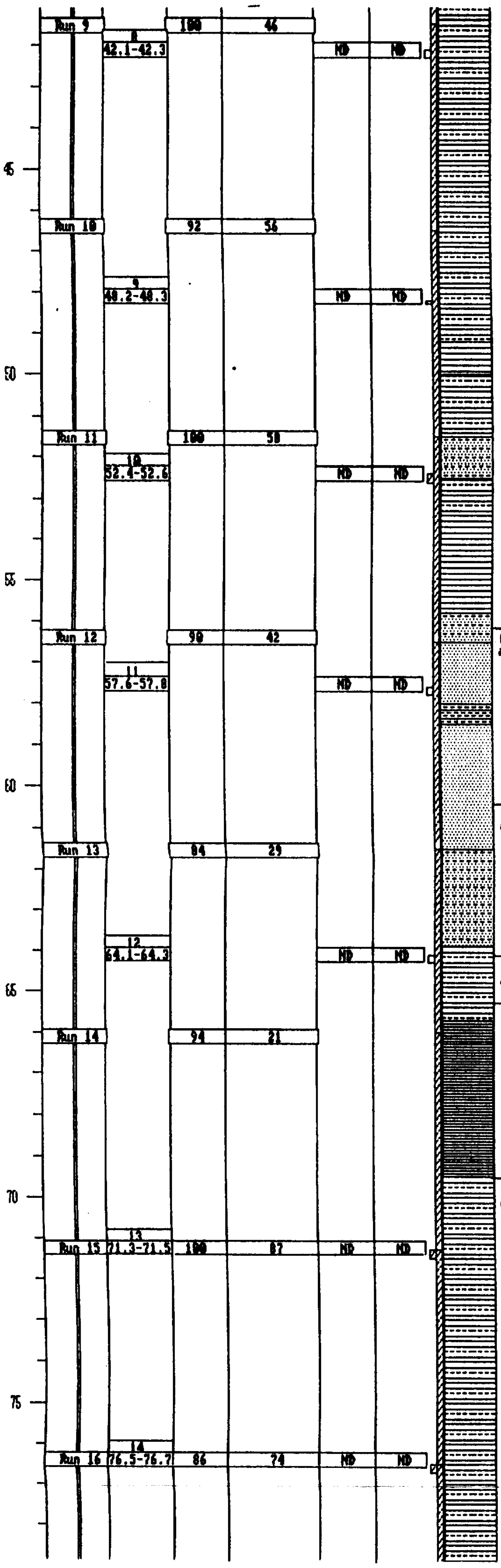
Discontinuity Log
Notation of Bedding and Fractures:
[DL, depth(s)/dip(s)°/comment(s)]

Hole Completion: Backfilled with grout

INDEX TO LITHOLOGIC SYMBOLS



LOG: EXPLORATORY HOLE 829-4 CONTINUED



[DL, 41.5-42.1/rubbly and fractured; fractures: 42.1-42.2/50°/lined with Mn-oxide, 42.8-43.5/4-20°/several, 43.6-43.8/70°/hackly and stained with Fe and Mn-oxide, and 43.8-43.9/50°, 70°/intersecting]

[DL, fractures: 44.2-44.5/70°/hackly, irregular, and coated with Fe and Mn-oxide, 44.9-45.2/1-20°, 1-50°/coated with Fe and Mn-oxide, 45.7-45.8/30°/coated with Mn-oxide, and 46.5/30°/coated with Mn-oxide]

46.5-48.1 feet: irregular light brown clay interbeds with yellow-brown claystone inclusions

[DL, 47.8-48/rubble; fractures: 48.3-48.6/70°, 48.3/30°, 30°/intersecting, 49.0/20°, 50.9/20°, 50.4/20°)irregular and healed with white (chalcedony?) coating, and 51.1/40°]

49.2-50.0 feet: light brown clay; 49.2-56.5 feet: scattered Fe-oxide spherules to 1/8 inch; 51.5-52.5 feet: medium brown silty sandstone

[DL, fractures: 51.5-51.6/30°, 52.7-53.4/90°/irregular, hackly, and lined with Fe and Mn-oxide, 54.4/30°/lined with Fe and Mn-oxide, and 55.1-55.4/50°/irregular and healed with Fe-oxide]

53.4-55.8 feet: light brown clay, interbedded with medium brown silty clay

55.8-56.5 feet: medium brown silty sandstone

(56.5-61.5) SANDSTONE: medium gray, fine grained, dark high angle cross beds

[DL, 56.5-57.7/rubbly and fractured; fractures: 57.2-57.3/20°, 57.9-58.2/55°/parallels cross-beds and lined with some white (chalcedony?), 59.3-59.4/30°, 40°/intersecting, and 59.7-59.9/90°/lined with Mn-oxide]

58.0-58.5 feet: light tan varved and cross-bedded clayey siltstone interbed; 59.4-59.5 feet: abundant hard clayey inclusions; at 60.8 feet: soft yellowish ½ inch inclusion

(61.5-63.9) SANDSTONE: SILTY, light to medium brown, very fine grained, minor clay

61.5-62.0 feet: minor coarse sand; 62.5-62.6 feet: light tan claystone lens

[DL, 61.5-61.6/rubble lined with Mn-oxide and white (chalcedony?); rubble: 62.2-62.6, and 65.1-65.3]

[DL, fractures: 61.5/30°, 62.0-62.2/60°, 62.2/40°, 60°, 80°/intersecting and partially lined with Mn-oxide and chalcedony, and 63.1/30°/lined with Fe-oxide]

(63.9-65.7) CLAY: SILTY [CL], medium brown, dries light tan, alternating soft and hard zones

(65.7-69.5) CLAYSTONE: light tan to pinkish brown

at 64.8 feet: 1 inch Fe-oxide inclusion; 66.0-66.7 feet: varved with Mn-oxide stained planes; at 69 feet: color changes to green

[DL, 66-71/mostly fractured and rubbly with abundant Fe and Mn-oxide]

[DL, fractures: 66.0-66.6/85°, 67.9-70.1/60°/healed with Fe and Mn-oxide; 67.4/10°, 85°/intersecting and lined with Fe-oxide, and 68.9-69.0/70°/in band of Fe-oxide]

(69.5-79.5) CLAY: SILTY [CL], green, locally crumbly, disseminated Fe-oxide

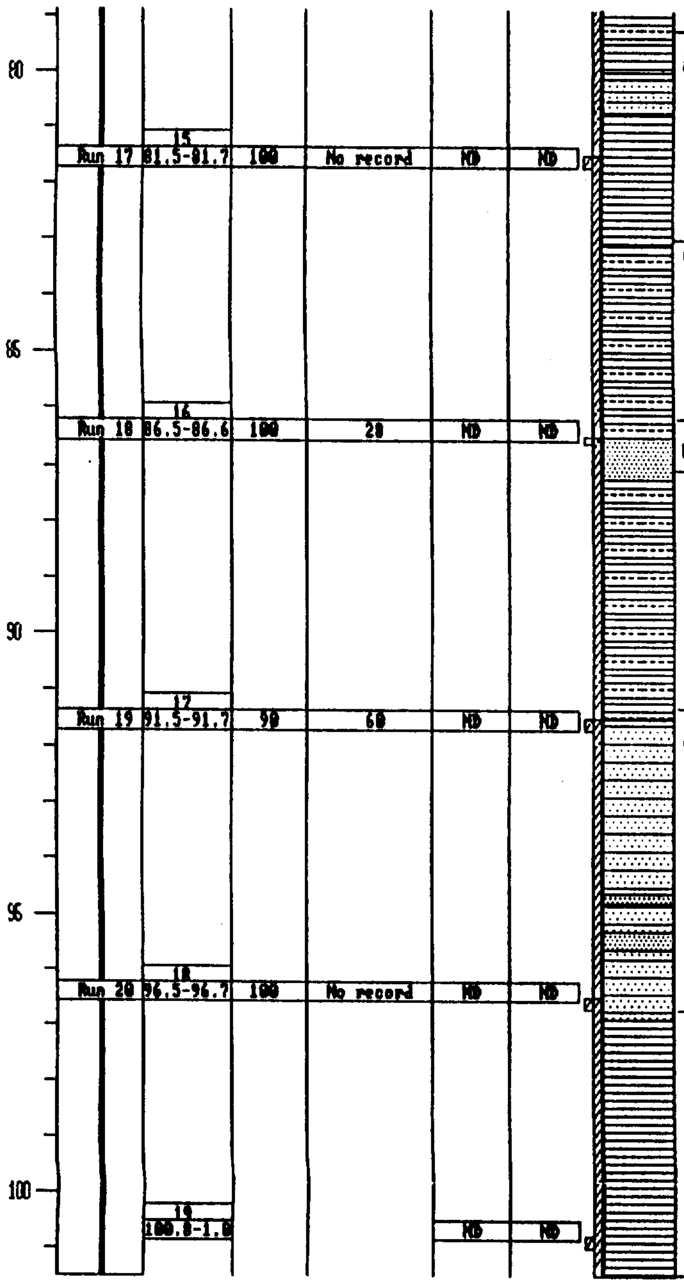
[DL, 69.4-69.5/30°/hackly fracture; Fe-oxide coated fractures: 70.5-70.6/30°, 71.5-71.6/35°/slickenslided, 72.6-72.7/30°, 73.9-74.0/30°/slickenslided, and 74.5-74.6/20°]

73.0-73.7 feet: common whitish inclusions and irregular circular Mn-oxide stains

76.5-79.5 feet: green-brown silty clay, silt content varies; 78.6-78.7 feet: green-brown clay interbed

[DL, 76.5-76.6/rubble and fractured pieces coated with Fe-oxide; 76.5-78.4/90°, ≈90°/Fe-oxide healed fractures, and stringers]

LOG: EXPLORATORY HOLE 829-4 CONTINUED



	15					
Run 17	81.5-81.7	100	No record	ND	ND	
	16					
Run 18	86.5-86.6	100	20	ND	ND	
	17					
Run 19	91.5-91.7	90	60	ND	ND	
	18					
Run 20	96.5-96.7	100	No record	ND	ND	
	19					
	100.8-1.0			ND	ND	

(79.5-83.1) CLAY: [CL], green brown, disseminated Fe-oxide, alternating lenses of minor silt

80-80.8 feet: green sandy clay interbed; 80.8-80.9 feet: band of blotchy Mn-oxide inclusions dip ≈25°

[DL, Fe-oxide lined fractures: 82.1-83.1/≈90°, and 83.8-84.0/0°/with chalcedony; 82.9-83.1/gouge and slickensides lined with Fe-oxide; 83.4-85/rubble]

(83.1-86.5) CLAY: SILTY [CL], mottled green brown, dry, crumbly

84.0-85.0 feet: color grades from green brown to yellow brown, disseminated Fe-oxide and chalcedony

(86.5-87.2) SANDSTONE: (or volcanic tuff?), medium gray, blotchy light and dark, hard

(87.2-91.5) CLAY: SILTY [CL], green brown

[DL, Fe-oxide coated fractures: 87.5-87.9/65°/healed, 87.8-87.9/45°, 89.0-89.2/60°, 90.0-90.3/70°, and 90.4-91.5/≈90°; 88.0-89.0/rubble]

(91.5-96.9) SAND: CLAYEY [SC], green brown, fine grained, abundant irregular blotches of Fe-oxide stains

[DL, fractures: 91.5-91.7/60°, 93.9-95.0/90°, ≈90°/healed with Fe-oxide, and 95.8-96.0/80°/coated with Fe-oxide; 93.5-93.9/rubble]

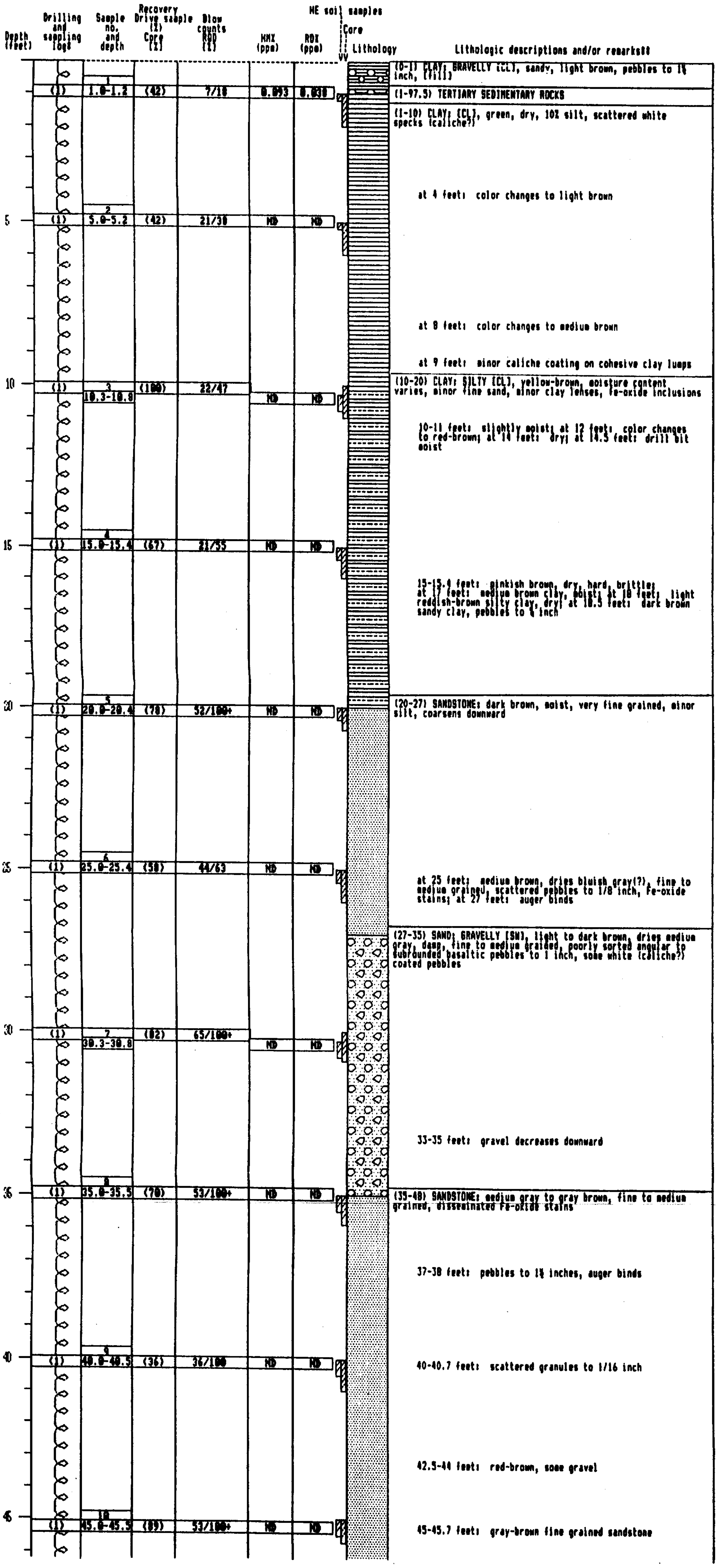
93.9-94.6 feet: thin white stringers; 94.6-94.8 and 95.3-95.6 feet: light gray, dry, hard sandstone interbeds

(96.9-101.5) CLAY: [CL], green brown, minor silt

96.9-98.8 feet: ≈½ inch thick bands of Fe-oxide stains; at ≈99.9 feet: color changes to red-brown

[DL, 96.5-99.4/rubble and fractured pieces; Fe-oxide coated fractures: 96.8-99.7/≈90°/scattered Mn-oxide stains, and 101.0-101.5/80°]

LOG: EXPLORATORY HOLE 829-5



Depth (feet)	Drilling and sampling log*	Sample no. and depth	Recovery Drive sample (%) Core (%)	Blow counts RQD (%)	HMX (ppm)	RDX (ppm)
	(1)	1 1.0-1.2	(42)	7/18	0.093	0.038
5	(1)	2 5.0-5.2	(42)	21/38	ND	ND
10	(1)	3 10.3-10.8	(100)	22/47	ND	ND
15	(1)	4 15.0-15.4	(67)	21/55	ND	ND
20	(1)	5 20.0-20.4	(78)	52/100+	ND	ND
25	(1)	6 25.0-25.4	(58)	44/63	ND	ND
30	(1)	7 30.3-30.8	(82)	65/100+	ND	ND
35	(1)	8 35.0-35.5	(70)	53/100+	ND	ND
40	(1)	9 40.0-40.5	(36)	36/100	ND	ND
45	(1)	10 45.0-45.5	(89)	53/100+	ND	ND

HE soil samples

Core

Lithology

Lithologic descriptions and/or remarks****

(0-1) CLAY: GRAVELLY [CL], sandy, light brown, pebbles to 1¼ inch, (fill)

(1-97.5) TERTIARY SEDIMENTARY ROCKS

(1-10) CLAY: [CL], green, dry, 10% silt, scattered white specks (caliche?)

at 4 feet: color changes to light brown

at 8 feet: color changes to medium brown

at 9 feet: minor caliche coating on cohesive clay lumps

(10-20) CLAY: SILTY [CL], yellow-brown, moisture content varies, minor fine sand, minor clay lenses, Fe-oxide inclusions

10-11 feet: slightly moist; at 12 feet: color changes to red-brown; at 14 feet: dry; at 14.5 feet: drill bit moist

15-15.4 feet: pinkish brown, dry, hard, brittle; at 17 feet: medium brown clay, moist; at 18 feet: light reddish-brown silty clay, dry; at 18.5 feet: dark brown sandy clay, pebbles to ¼ inch

(20-27) SANDSTONE: dark brown, moist, very fine grained, minor silt, coarsens downward

at 25 feet: medium brown, dries bluish gray(?), fine to medium grained, scattered pebbles to 1/8 inch, Fe-oxide stains; at 27 feet: auger binds

(27-35) SAND: GRAVELLY [SW], light to dark brown, dries medium gray, damp, fine to medium grained, poorly sorted angular to subrounded basaltic pebbles to 1 inch, some white (caliche?) coated pebbles

33-35 feet: gravel decreases downward

(35-48) SANDSTONE: medium gray to gray brown, fine to medium grained, disseminated Fe-oxide stains

37-38 feet: pebbles to 1¼ inches, auger binds

40-40.7 feet: scattered granules to 1/16 inch

42.5-44 feet: red-brown, some gravel

45-45.7 feet: gray-brown fine grained sandstone

EXPLORATORY HOLE 829-5

Geologic Logging:
P. Webster-Scholten,
D. Carpenter, LLNL

Hole Location:
In roadway outside of gates
at B-829 burn pit

Coordinates:
N: 417,277.6
E: 1,703,158.7

Ground Elevation: 1080.38 feet

Geophysical Logging: None

Drilling:
D. Wagster, P. C. Exploration Inc.,
Roseville, CA

Dates Drilled: 12/12 to 12/15/86

Drilling Method:
9-inch hollow stem auger 0-50 feet
4¾-inch air/mist rotary 50-97.5 feet

* Key: Drilling and Sampling Log

9-inch hollow stem auger

(1) 1⅞-inch diameter sample taken with 2-inch O.D. split tube sampler driven by 140-lb. weight falling 30 inches. Samples encased in stainless steel sleeves, sealed with aluminum foil, and inert duct tape.

Run # Core obtained using Christensen HQ (4¾ inch) Wireline Punch Core System. Samples taken from core, placed in glass jar, and sealed with inert duct tape.

ND None detected above detection limit. Detection limits vary with the amount of sample tested. Range of detection limits for this hole:

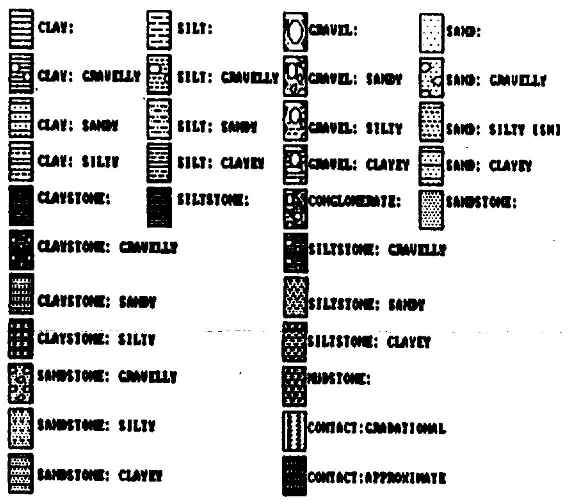
HMX = 0.0005 ppm
RDX = 0.0006 ppm
TNT = 0.0005 ppm (not shown on log)

** Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates.

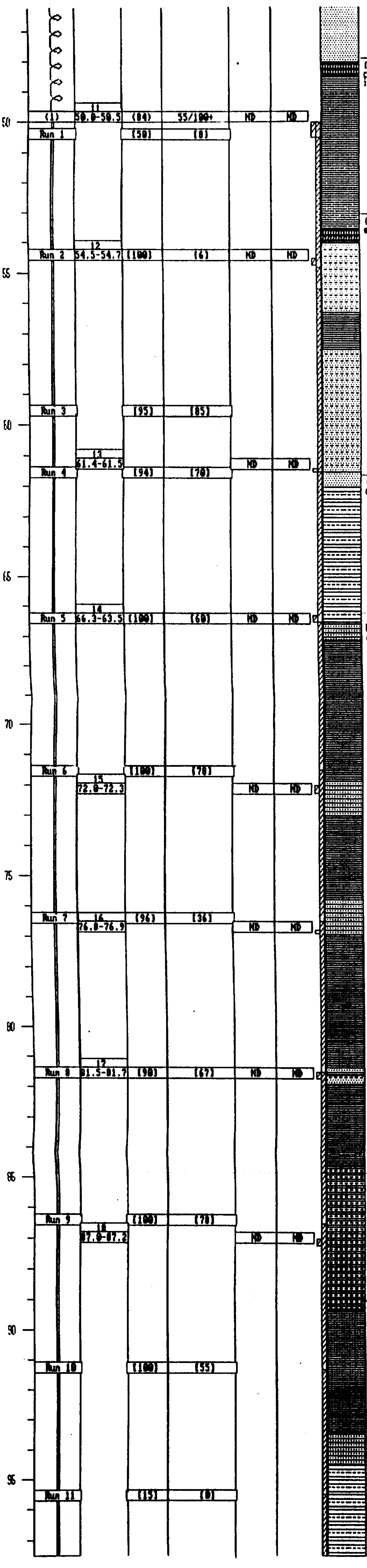
Discontinuity Log,
Notation of Bedding and Fractures:
[DL, depth(s)/dip(s)°/comment(s)]

Hole Completion: Backfilled with grout

INDEX TO LITHOLOGIC SYMBOLS



LOG: EXPLORATORY HOLE 829-5 CONTINUED



(48-53.5) SILTSTONE: dark gray-brown, damp to wet, grades from clayey to sandy near 50.5 feet, locally abundant hard clayey inclusions dip 25°, minor white (caliche?) inclusions

[DL, 50.0-50.6/rubble; fractures: 50.9/50°, 51.2/60°, and 51.5/40°]

(53.5-62) SANDSTONE: SILTY, medium to dark gray, fine to medium grained, well compacted

54.5-54.9 feet: interlaminated light and dark layers; 54.9-56.3 feet: abrupt color change to green-brown

[DL, 55.2/caliche?; 54.5-59.5/40-90°/highly fractured and rubbly core with common Mn and Fe-oxide stains; 54.5-54.9/±0°/laminations; 56.0/abundant mud clasts]

56.3-57.5 feet: medium brown hard claystone interbed; 61.5-62.0 feet: medium to dark gray fine grained sandstone

(62-66.5) CLAY: SILTY [CL], medium brown, grades locally into clayey siltstone

[DL, 61.5-62.1/highly fractured; fractures: 62.1/80°, 64.5/45°, and 66.0/10°; 64.6-64.9/abundant mud clasts]

(66.5-84.6) CLAYSTONE: locally sandy, green brown to medium brown, poorly to moderately lithified, very fine to fine sand, abundant Fe and Mn-oxide stains

66.5-67.1 feet: greenish brown sandy claystone interbed; 67.1-68.0 feet: claystone; 68.0-71.8 feet: some pinkish brown coloration, some silt and fine sand

[DL, 68.5-73.2/10°, 55°, ±90°/very intensely fractured, coated with Fe and Mn-oxide; 73.7-74.1/±90°/irregular fractures healed with Fe-oxide]

71.8-73 feet: poorly lithified sandy claystone, very fine sand, abundant silt

73-75.7 feet: olive claystone, trace of silt and fine sand, moderately plastic, occasional nodules of very fine silty sand; 75.7-77.0 feet: yellow brown sandy claystone, moderately lithified

[DL, 76.0/25°/Fe-oxide stained joint; 76.0-76.2/25°, ±90°/ Fe-oxide stained very intense fracture zone; 76.5-77.9/15-25°, 40°, 70-90°/Fe and Mn-oxide stained very intense fracture zone]

77-81.3, 81.5-81.6 and 81.9-84.6 feet: olive brown claystone, moderately hard, silty, trace of fine sand

81.3-81.5 feet: yellow brown sandy claystone, silty; 81.6-81.9 feet: brown very fine grained silty sandstone

[DL, joints: 78.3-80.2/±90°/partially healed with Fe-oxide, 79.2/±90°/joint branches, 82.3-82.6/±90°/healed with Fe-oxide, and 83.2-83.6/75°, ±90°/intersecting, partially healed with Fe and Mn-oxide]

(84.6-89.3) CLAYSTONE: SILTY, dark gray-green, low plasticity, abundant Fe-oxide stains, abundant light gray laminae (decomposed tuff fragments and chalcedony veinlets?) dip ±5° and ±90°

[DL, joints: 84.8/20°/Fe-oxide stained, 84.6-85.2/±90°/irregular, slickenslided, 87.3/15°/clay coated, and 89.3/15°/clay coated; 88.3-88.4/30-40°/slickenslide shear planes, clay coated]

(89.3-93.4) SILTSTONE: tuffaceous, mottled light and dark gray, abundant hard chalcedony healings and siliceous oolites to ¼ inch, grades browner with loss of oolites with depth

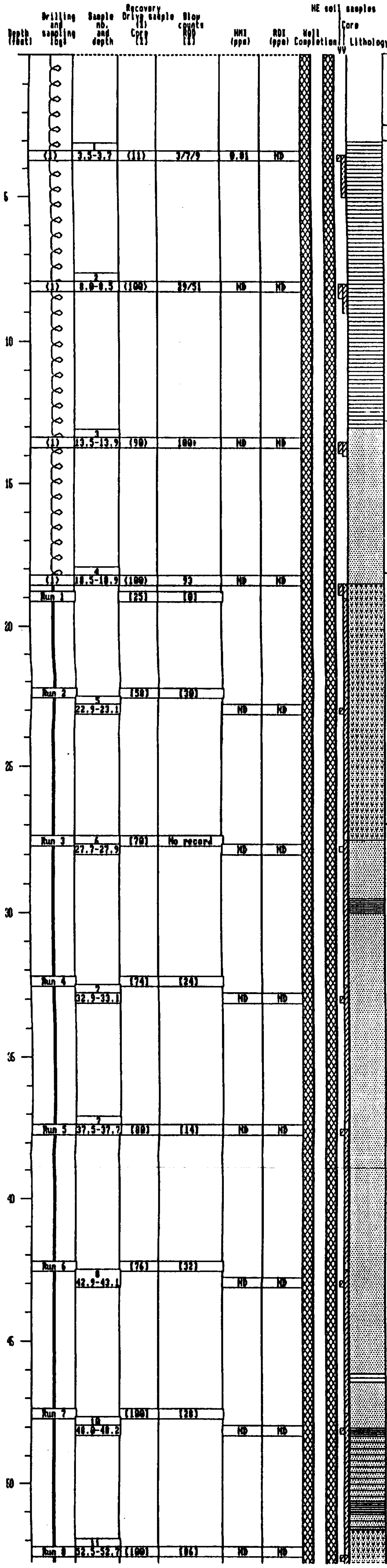
[DL, Fe-oxide stained very intense fracture zones: 91.2-91.6/45°, 50°, ±90°, and 92.9-93.5/40°, 80°/intersecting, partially healed with chalcedony]

[DL, Fe-oxide stained joints: 90.9/?, and 92.1-92.6/70°, 85°/intersecting; 95.5-97.5/poor recovery]

(93.4-94.5) CLAYSTONE: SANDY, brown with yellow Fe-oxide stains, similar to 71.8-73 feet

(94.5-97.5) CLAY: SILTY [CL], brown, hard, not lithified, moderately plastic, becomes slightly lithified below 96 feet

LOG : PIEZOMETER 829-06



Drilling and sampling log	Sample no. and depth	Recovery Drive sample (%) Core (%)	Blow counts RQD (%)	HMX (ppm)	RDX (ppm)
(1)	1 3.5-3.7	(11)	3/7/9	0.01	ND
(1)	2 8.0-8.5	(100)	29/51	ND	ND
(1)	3 13.5-13.9	(90)	100+	ND	ND
(1)	4 18.5-18.9	(100)	93	ND	ND
Run 1		[25]	[0]		
Run 2	5 22.9-23.1	[50]	[30]	ND	ND
Run 3	6 27.7-27.9	[70]	No record	ND	ND
Run 4	7 32.9-33.1	[74]	[24]	ND	ND
Run 5	8 37.5-37.7	[80]	[14]	ND	ND
Run 6	9 42.9-43.1	[76]	[32]	ND	ND
Run 7	10 48.0-48.2	[100]	[20]	ND	ND
Run 8	11 52.5-52.7	[100]	[86]	ND	ND

Lithologic descriptions and/or remarks‡‡

(0-3) Fill

(3-99.5) TERTIARY SEDIMENTARY ROCKS

(3-13) CLAY: [CL], dark brown, damp, minor whitish inclusions

8-8.5 feet: medium brown, dry, scattered pebbles to 1/8 inch; 8.5-13 feet: increasing pebbles to ¼ inch

(13-18.5) SANDSTONE: medium brown, dries medium gray, hard, compact, very fine grained, minor silt

(18.5-27.5) SANDSTONE: SILTY, dark brown, fine to medium grained, coarsens downward

18.5-18.6 feet: minor Fe-oxide stained clay lens

[DL, 18.5-22.6/rubble; fractures: 23.0/30°, 23.5/20°, 24.0/30°, 24.5/30°, 24.5-25.4/80°, and 25.2/10°]

24-27.5 feet: difficult coring

(27.5-40) SANDSTONE: dark brown, dries blue-gray, mostly fine to medium grained, 15% coarse sand, coarsens downward, minor medium brown clay lenses

[DL, 27.5-27.9/rubble; fractures: 27.8/40°, and 28.1-28.5/75°; fractures coated with Mn-oxide: 29.5/10°, 29.5-30.0/85°, and 30.6/0°]

29.5-31.0 feet: greenish brown, dry, hard, well compacted, claystone interbed, minor silt

[DL, 32.5-32.9/rubble with Mn-oxide coated fractures; fractures: 32.9-33.7/90°, 34.3-34.6/40°, 34.6-34.8/70°, and 34.9/35°]

37.5-40 feet: disseminated hard clayey inclusions

[DL, 37.5-39.1/50°/bedding; 37.5-38.1/core rubbley and fragmented; fractures: 37.5-39.2/30°-40°/several, 39.2-40.1/80°/hackly, 40.1/30°, 80/intersecting, and 40.3-40.6/10°/hackly; Fe-oxide in some healed fractures]

42.5-48 feet: dry, hard, common Mn-oxide stains

[DL, 42.5-42.9/rubble; 45.3-46.2/rubble with Fe-oxide; fractures: 43.9/50°, 44.5-45.0/60°/hackly, and 45.2-45.4/60°; 46.2-46.4/10-20°/bedding]

46.2-46.4 feet: clay interbed

(48-51.6) SANDSTONE: CLAYEY, gray-brown, dry, hard, fine grained, some hard clayey inclusions

48.0-48.2 feet: medium brown claystone interbed; 50.6-51.6 feet: medium brown, grades from claystone to sandstone

[DL, fractures: 48.1-48.4/60°(coated with Mn and Fe-oxide, 48.4-48.6/70°, 48.6/30°, 70°/intersecting, 49.3/10°(coated with Fe-oxide, 49.3/70°/hackly, and 50.0-50.6/80°]

(51.6-56.5) SANDSTONE: SILTY, medium brown, dry, hard, increasing clay with depth

PIEZOMETER 829-6

Geologic Logging:
P. Webster-Scholten, LLNL

Hole Location:
In ditch outside northwest corner
of fenced HE drying area at B-827

Coordinates:
N: 417,201.5
E: 1,703,230.4

Ground Elevation: 1068.48 feet

Geophysical Logging: None

Drilling:
D. Wagster, P. C. Exploration Inc.,
Roseville, CA

Dates Drilled: 12/16 to 12/18/86

Drilling Method:
9-inch hollow-stem auger 0-18.5 feet
4¾-inch air/mist rotary 18.5-99.5 feet

‡ Key: Drilling and Sampling Log

9-inch hollow-stem auger

(1) 1⅜-inch diameter sample taken with 2-inch O.D. split tube sampler driven by 140-lb. weight falling 30 inches. Samples encased in stainless steel sleeves, sealed with aluminum foil, and inert duct tape.

Run 8 Core obtained using Christensen HQ (4⅝ inch) Wireline Punch Core System. Samples taken from core, placed in glass jar, and sealed with inert duct tape.

ND None detected above detection limit. Detection limits vary with the amount of sample tested. Range of detection limits for this hole:

HMX = <0.0004 - <0.0007 ppm
RDX = <0.0008 - <0.0015 ppm
TNT = 0.0006 ppm (not shown on log)

‡‡ Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates.

Discontinuity Log,
Notation of Bedding and Fractures:
[DL, depth(s)/dip(s)°/comment(s)]

Ground Water: 92 feet

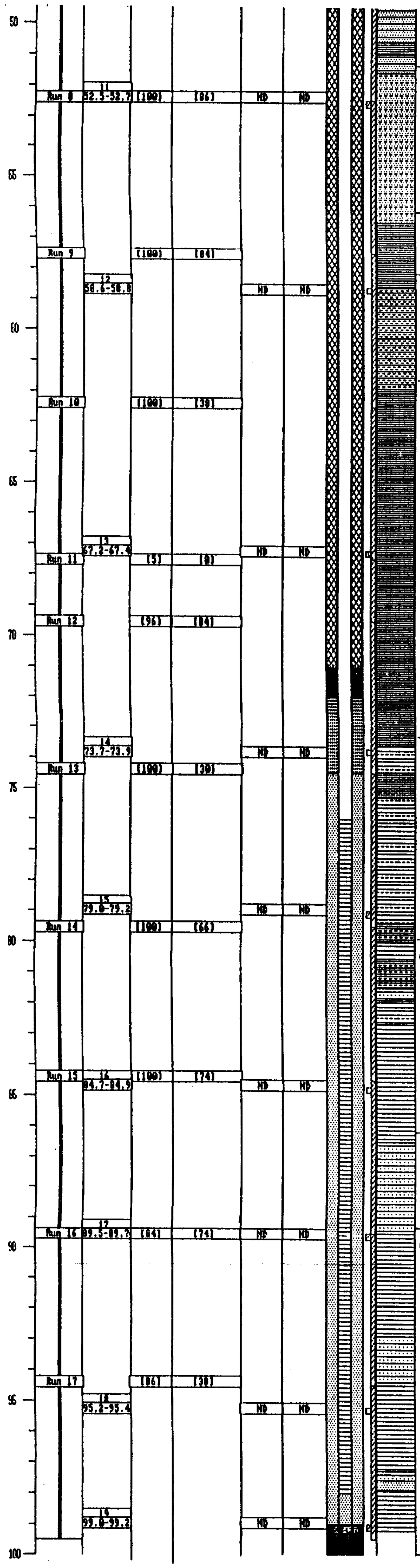
Piezometer Completion:

- ☐ CASING: 3 inch I.D. threaded PVC
- ☰ SCREEN: 3 inch I.D. threaded PVC
- ░ FINE SAND: #0 Sand
- ▒ SAND PACK: #3 Sand
- ■ BENTONITE SEAL
- ▩ ANNULAR SEAL: Cement Grout
- ▦ SLOUGH:MATERIAL

INDEX TO LITHOLOGIC SYMBOLS

- CLAY:
- CLAY: GRAVELLY
- CLAY: SANDY
- CLAY: SILTY
- CLAYSTONE:
- CLAYSTONE: GRAVELLY
- CLAYSTONE: SANDY
- CLAYSTONE: SILTY
- SANDSTONE: GRAVELLY
- SANDSTONE: SILTY
- SANDSTONE: CLAYEY
- SILT:
- SILT: GRAVELLY
- SILT: SANDY
- SILT: CLAYEY
- SILTSTONE:
- GRAVEL:
- GRAVEL: SANDY
- GRAVEL: SILTY
- GRAVEL: CLAYEY
- CONGLOMERATE:
- SILTSTONE: GRAVELLY
- SILTSTONE: SANDY
- SILTSTONE: CLAYEY
- MUDSTONE:
- CONTACT:GRADATIONAL
- CONTACT:APPROXIMATE
- SAND:
- SAND: GRAVELLY
- SAND: SILTY (SM)
- SAND: CLAYEY
- SANDSTONE:

LOG : PIEZOMETER 829-06 (cont.)



[DL, fractures: 48.1-48.6/60°/coated with Mn and Fe-oxide, 48.4-48.6/70°, 48.6/30°, 70°/intersecting, 49.1/10°/coated with Fe-oxide, 49.3/70°/hackly, and 50.0-50.6/80°]

(51.6-56.5) SANDSTONE: SILTY, medium brown, dry, hard, increasing clay with depth

[DL, fractures: 51.6-51.9/60°, 90°/intersecting and coated with chalcedony, and 52.1-52.3/40°/coated with Mn-oxide; Fe and Mn-oxide coated fractures dip 30° at: 56.8, 57.3, and 57.5 feet]

(56.5-58.6) CLAYSTONE: light to medium brown

57.3-57.5 feet: yellow-brown siltstone interbed with disseminated Fe-oxide

(58.6-61.9) SILTSTONE: CLAYEY, medium brown

60.5-60.8 feet: common clayey inclusions

[DL, fractures: 58.4-58.6/70°/hackly with some Mn-oxide, 59.7-60.1/80°/lined with Mn-oxide, 60.2-60.5/50°/healed with chalcedony, 61.7-61.9/30°/lined with Fe-oxide, and 61.9-62.2/90°/insipient]

(61.9-73.6) CLAYSTONE: medium brown, locally green-brown or pinkish brown, dry, hard

[DL, 62.5-63.6/rubble; fractures: 63.0-63.9/90°, and 63.2/0°/lined with Mn-oxide; healed fractures at: 65.5, and 66.1-67; Fe-oxide coated fractures at: 64.6/10°, 65.9/20°, and 66.9/10°; 67.5-69.5/poor recovery]

62.5-66.9 feet: locally varved with dark horizontal bedding planes; 63.4-63.5 feet: clay lens, wet, soft

66.9-73.6 feet: green claystone, crumbly, disseminated with Fe-oxide; at 71.5 feet: ¼ inch white lens; 72.6-73.3 feet: increasing silt

(73.6-79.4) CLAY: SILTY [CL], interbedded with clay and siltstone, green-brown, hardness varies

[DL, 73.9/Fe-oxide coating at bottom of core; fractures: 74.5/20°/coated with Mn-oxide, 76.3-79.2/partially coated with chalcedony and Fe-oxide, and 76.8-77.4/70°; 74.5-75.4/irregular planes of Mn and Fe-oxide]

74.5-75.3 feet: dry, hard green-gray siltstone; 76.0-76.2 feet: green-brown clay; 79.5-80.0, and 80.6-81.5 feet: green silty claystone, compact

(79.4-86.5) CLAY: [CL], green, soft, compact to mushy, some claystone, silty clay and sandy clay interbeds

81.5-81.9 feet: green sandy clay, clumpy; 82.2-82.6 feet: green, soft, compact, silty clay, with mottled inclusions of Fe and Mn-oxide; 82.8-84.3, and 85.5-86.5 feet: white mottling, <5% silt

[DL, 79.5-80.0/rubble; 80.7-81.5/90°, hackly/fracture zone with slickenslides and Fe-oxide; fractures: 84.3/20°, 87.1-87.2/40°, 87.6-88.0/30°, 40°/some chalcedony, and 86.9/20°/Fe-oxide healed]

(86.5-89.5) CLAY: SANDY [CL], green with white mottling

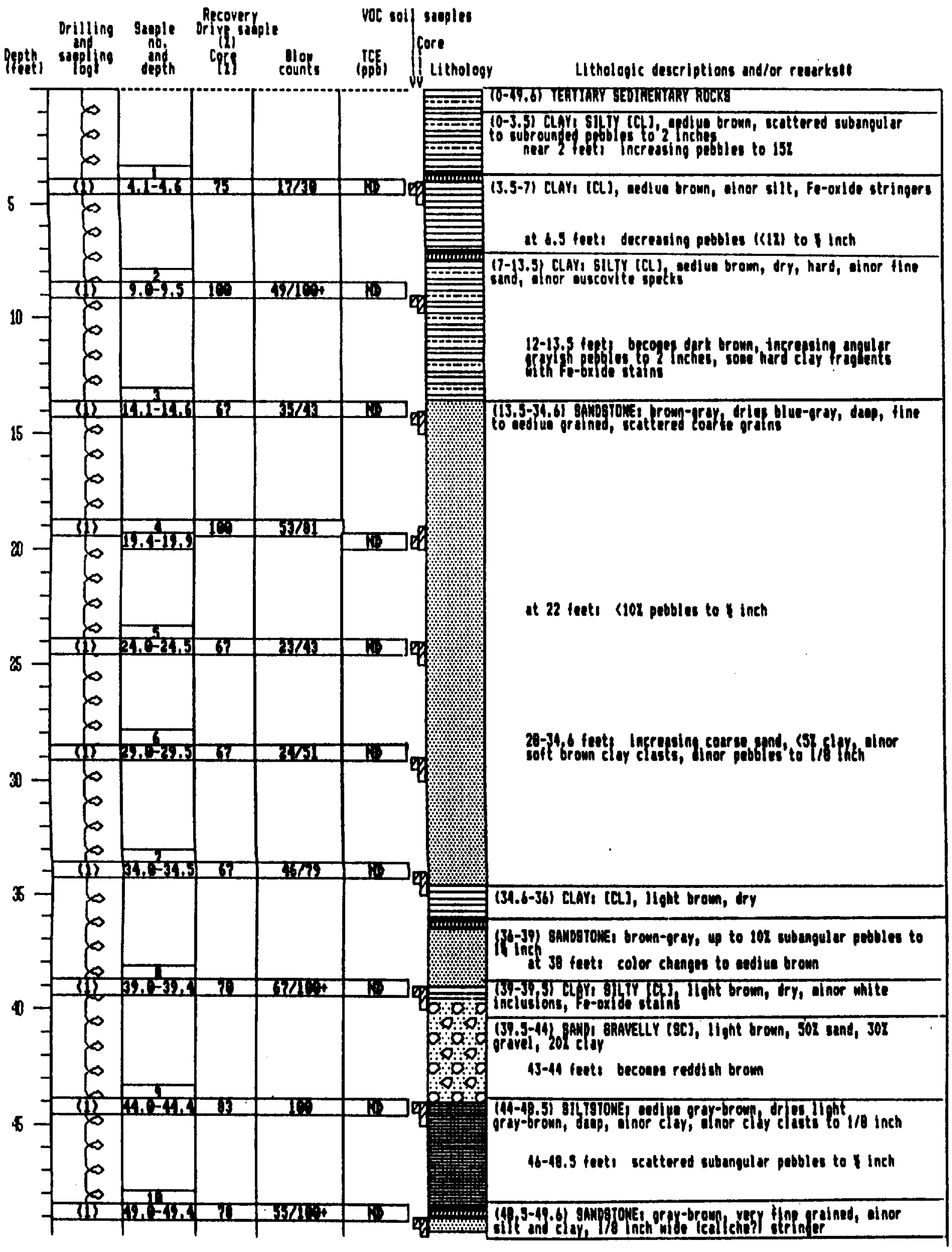
88.6-88.7 feet: gravelly

(89.5-99.2) CLAY: [CL] to silty clay, locally sandy, green, disseminated Fe-oxide, disseminated white inclusions (tuff?) to 1 inch

91.8-91.9, 92.8-94.5, and 97.3-97.6 feet: sandy clay 97.6-97.9 feet: gray-green, hard, very fine sandstone

[DL, 90.7-91.9/≤90°/hackly fracture; rubble: 93.0-93.7 and 97.3-97.6 feet; 97.5/hackly fracture lined with Fe and Mn-oxide; 99.2/hackly fracture lined with Fe-oxide]

LOG: EXPLORATORY HOLE 829-7



Drilling and sampling log*	Sample no. and depth	Recovery Drive sample (%) Core (%)	Blow counts	TCE (ppb)
(1)	1 4.1-4.6	75	17/30	ND
(1)	2 9.0-9.5	100	49/100+	ND
(1)	3 14.1-14.6	67	35/43	ND
(1)	4 19.4-19.9	100	53/81	ND
(1)	5 24.0-24.5	67	23/43	ND
(1)	6 29.0-29.5	67	24/51	ND
(1)	7 34.0-34.5	67	46/79	ND
(1)	8 39.0-39.4	70	67/100+	ND
(1)	9 44.0-44.4	83	100	ND
(1)	10 49.0-49.4	70	55/100+	ND

Lithologic descriptions and/or remarks**

(0-49.6) TERTIARY SEDIMENTARY ROCKS

(0-3.5) CLAY: SILTY [CL], medium brown, scattered subangular to subrounded pebbles to 2 inches
near 2 feet: increasing pebbles to 15%

(3.5-7) CLAY: [CL], medium brown, minor silt, Fe-oxide stringers

at 6.5 feet: decreasing pebbles (<1%) to ¼ inch

(7-13.5) CLAY: SILTY [CL], medium brown, dry, hard, minor fine sand, minor muscovite specks

12-13.5 feet: becomes dark brown, increasing angular grayish pebbles to 2 inches, some hard clay fragments with Fe-oxide stains

(13.5-34.6) SANDSTONE: brown-gray, dries blue-gray, damp, fine to medium grained, scattered coarse grains

at 22 feet: <10% pebbles to ¼ inch

28-34.6 feet: increasing coarse sand, <5% clay, minor soft brown clay clasts, minor pebbles to 1/8 inch

(34.6-36) CLAY: [CL], light brown, dry

(36-39) SANDSTONE: brown-gray, up to 10% subangular pebbles to 1¼ inch
at 38 feet: color changes to medium brown

(39-39.5) CLAY: SILTY [CL], light brown, dry, minor white inclusions, Fe-oxide stains

(39.5-44) SAND: GRAVELLY [SC], light brown, 50% sand, 30% gravel, 20% clay

43-44 feet: becomes reddish brown

(44-48.5) SILTSTONE: medium gray-brown, dries light gray-brown, damp, minor clay, minor clay clasts to 1/8 inch

46-48.5 feet: scattered subangular pebbles to ¼ inch

(48.5-49.6) SANDSTONE: gray-brown, very fine grained, minor silt and clay, 1/8 inch wide (caliche?) stringer

EXPLORATORY HOLE 829-7

Geologic Logging:
P. Webster-Scholten, LLNL

Hole Location:
In middle of B-829 HE burn pit No. 2, 4 feet
southwest of exploratory hole 829-1, Site 300

Coordinates:
N: 417,314.8
E: 1,703,085.3

Ground Elevation: 1071.50 feet

Geophysical Logging: None

Drilling:
D. Wagster, P. C. Exploration Inc.,
Roseville, CA

Dates Drilled: 1/8/87

Drilling Method:
9-inch hollow stem auger 0-49 feet

* Key: Drilling and Sampling Log

9-inch hollow stem auger

(1) 1-1/2-inch diameter sample taken with 2-inch O.D. split tube sampler driven by 140-lb. weight falling 30 inches. Samples encased in stainless steel sleeves, sealed with aluminum foil, and inert duct tape.

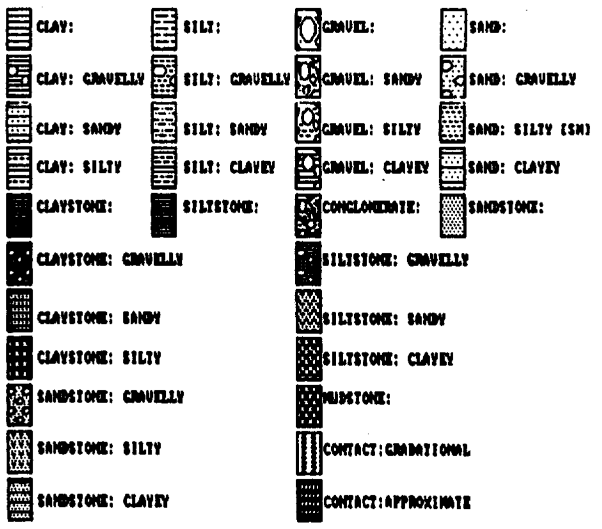
ND None detected (TCE < 0.0002 ppm)

** Where given, percentages of sands, gravels, and fines represent field visual (e.g., volumetric) estimates.

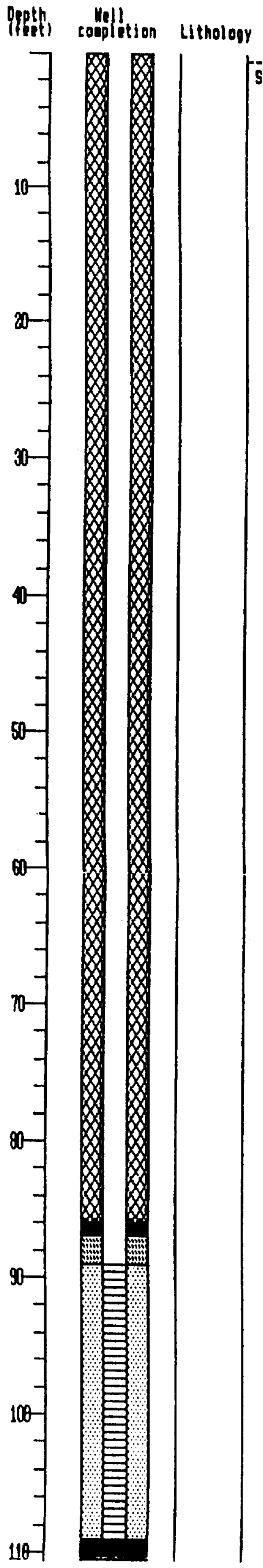
Ground Water: Not encountered

Hole Completion: Backfilled with grout

INDEX TO LITHOLOGIC SYMBOLS



LOG: MONITOR WELL W-829-08



Lithologic descriptions and/or remarks**

See lithology from nearby Monitor Well W-829-06

MONITOR WELL W-829-08

Geologic Logging:
See Piezometer W-829-06

Hole Location:
Approximately 40 feet northeast of
Piezometer W-829-06, east of B-829, Site 300

Coordinates:
N: 417,236.7
E: 1,703,252.0

Elevation: Shiner 1071.75 feet
Top of protective casing (TOSP) 1074.75 feet

Geophysical Logging: None

Drilling:
D. Wagster, P. C. Exploration Inc.,
Roseville, CA

Date Drilled: 1/14/87

Drilling Method:
9-inch tricone bit, air-mist rotary
0-111.7 feet

Ground Water:
3/4/88 water was 98.8 feet below TOSP.
7/7/88 water was 98.8 feet below TOSP.

Monitor Well Completion:

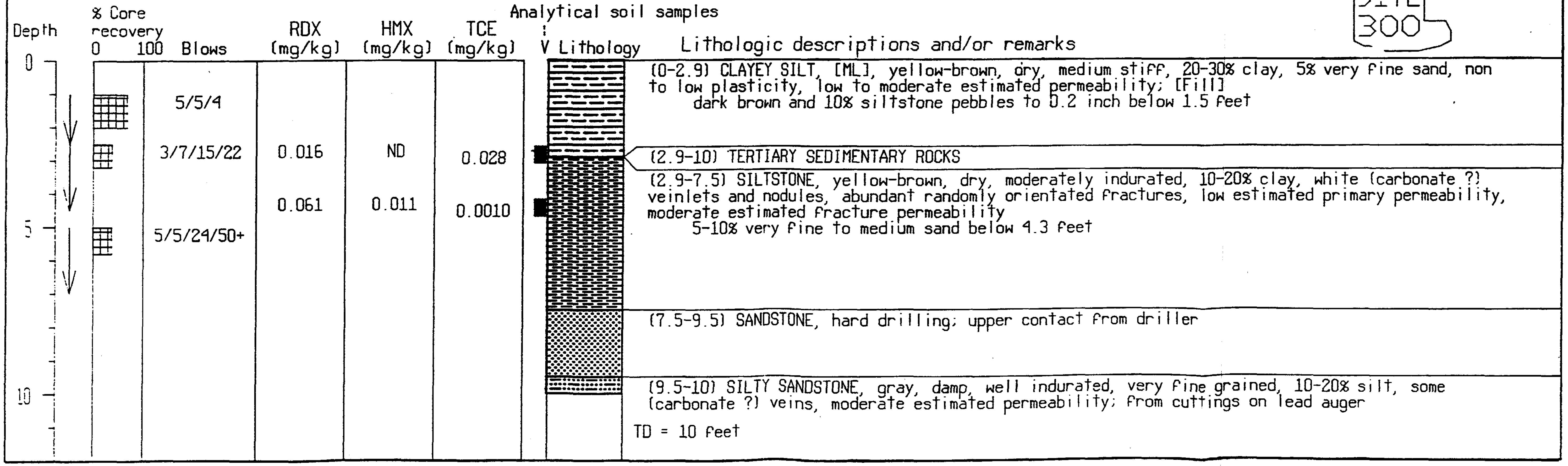
☐ PVC CASING
▤ SLOTTED CASING
▦ FINE SAND: #0 Sand
░ SAND PACK: #3 Sand
■ BENTONITE
▩ ANNULAR SEAL: Cement Grout
≋ SLOUGH:MATERIAL

LOG: BOREHOLE 829-09

Geologic Logging: E. Anderson, Weiss Associates, Emeryville, CA
Borehole Location: Approximately 12 feet west of Burn Pit 3,
Building 829 Area, Site 300
Coordinates: N: 417,369.8; E: 1,703,072.0
Elevation (ground): 1081.37 feet
Drilling: D. Wagster, P. C. Exploration, Inc., Roseville, CA
Date Drilled: 8/10/90
Sampling Methods: 2.5-inch I.D. split-spoon sampler at 1 foot and
1.4-inch split-spoon sampler at 2.5 and 4 feet.
sampler advanced by 140-pound weight falling 30 inches.
Arrows show locations of sampling.

Drilling Method: 8-inch hollow stem auger, 0-10 feet
Borehole backfilled with cuttings.
Ground Water: Not observed during drilling.
Analytical Notes: No VOC constituents (excluding TCE which is shown
on the log) were identified above 0.0002 mg/kg.
No soluble metals were identified above the STLC in soil from
2.8 and 4.4 feet.
The dectection limit for HMX and RDX is 0.001 mg/kg.
ND means none detected
Recovery histograms show percent recovery and inferred recovery locations.
Estimates of gravels, sands, and fines are field visual estimates.

SITE 300



Blows	RDX (mg/kg)	HMX (mg/kg)	TCE (mg/kg)
5/5/4			
3/7/15/22	0.016	ND	0.028
	0.061	0.011	0.0010
5/5/24/50+			

Lithologic descriptions and/or remarks

(0-2.9) CLAYEY SILT, [ML], yellow-brown, dry, medium stiff, 20-30% clay, 5% very fine sand, non to low plasticity, low to moderate estimated permeability; [Fill]
dark brown and 10% siltstone pebbles to 0.2 inch below 1.5 feet

(2.9-10) TERTIARY SEDIMENTARY ROCKS

(2.9-7.5) SILTSTONE, yellow-brown, dry, moderately indurated, 10-20% clay, white (carbonate ?) veinlets and nodules, abundant randomly orientated fractures, low estimated primary permeability, moderate estimated fracture permeability
5-10% very fine to medium sand below 4.3 feet

(7.5-9.5) SANDSTONE, hard drilling; upper contact from driller

(9.5-10) SILTY SANDSTONE, gray, damp, well indurated, very fine grained, 10-20% silt, some (carbonate ?) veins, moderate estimated permeability; from cuttings on lead auger

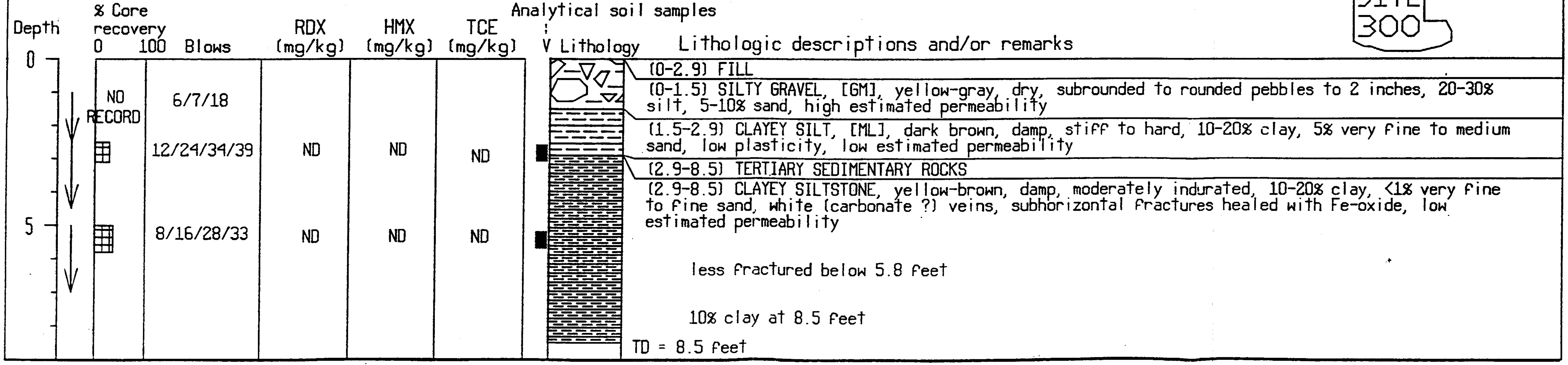
TD = 10 feet

LOG: BOREHOLE 829-10

Geologic Logging: E. Anderson, Weiss Associates, Emeryville, CA
Borehole Location: Approximately 5 feet northwest of Burn Pit 2,
Building 829 Area, Site 300
Coordinates: N: 417,314.3; E: 1,703,055.8
Elevation (ground): 1080.00 feet
Drilling: D. Wagster, P. C. Exploration, Inc., Roseville, CA
Date Drilled: 8/10/90
Sampling Methods: 2.5-inch I.D. split-spoon sampler at 1 feet and
1.4-inch split-spoon sampler at 2.5 and 5 feet.
sampler advanced by 140-pound weight falling 30 inches.
Arrows show locations of sampling.

Drilling Method: 8-inch hollow stem auger, 0-8.5 feet
Borehole backfilled with cuttings.
Ground Water: Not observed during drilling.
Analytical Notes: No VOC constituents were identified above 0.0002 mg/kg.
No soluble metals were identified above the STLC in soil from
2.8 and 5.4 feet.
The dectection limit for HMX and RDX is 0.001 mg/kg.
ND means none detected.
Recovery histograms show percent recovery and inferred recovery locations.
Estimates of gravels, sands, and fines are field visual estimates.

SITE 300



Depth	Blows	RDX (mg/kg)	HMX (mg/kg)	TCE (mg/kg)
	6/7/18			
	12/24/34/39	ND	ND	ND
5	8/16/28/33	ND	ND	ND

Lithologic descriptions and/or remarks

(0-2.9) FILL

(0-1.5) SILTY GRAVEL, [GM], yellow-gray, dry, subrounded to rounded pebbles to 2 inches, 20-30% silt, 5-10% sand, high estimated permeability

(1.5-2.9) CLAYEY SILT, [ML], dark brown, damp, stiff to hard, 10-20% clay, 5% very fine to medium sand, low plasticity, low estimated permeability

(2.9-8.5) TERTIARY SEDIMENTARY ROCKS

(2.9-8.5) CLAYEY SILTSTONE, yellow-brown, damp, moderately indurated, 10-20% clay, <1% very fine to fine sand, white (carbonate ?) veins, subhorizontal fractures healed with Fe-oxide, low estimated permeability

less fractured below 5.8 feet

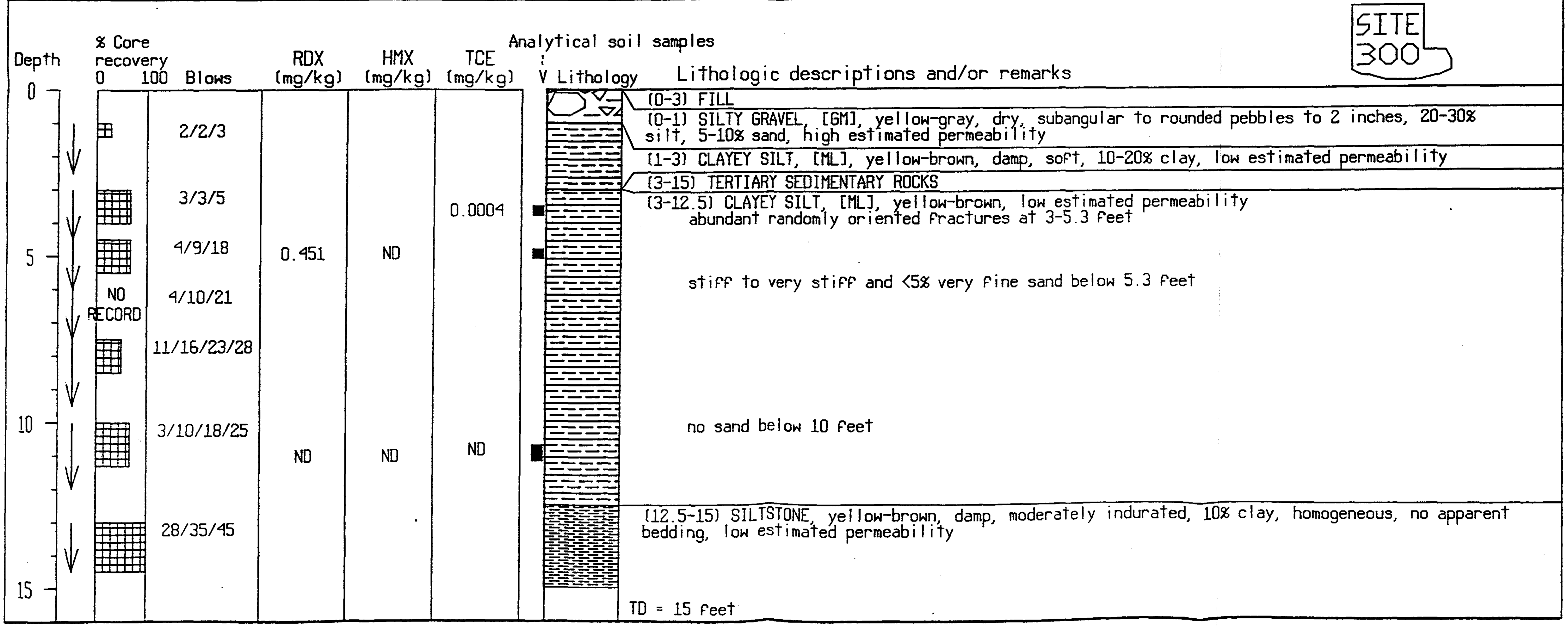
10% clay at 8.5 feet

TD = 8.5 feet

LOG: BOREHOLE 829-11

Geologic Logging: E. Anderson, Weiss Associates, Emeryville, CA
Borehole Location: Approximately 4 feet north of Burn Pit 1,
Building 829 Area, Site 300
Coordinates: N: 417,276.6; E: 1,703,080.0
Elevation (ground): 1079.74 feet
Drilling: D. Wagster, P. C. Exploration, Inc., Roseville, CA
Date Drilled: 8/10/90
Sampling Methods: 2.5-inch I.D. split-spoon sampler at 2.5 and 6 feet; 1.4-inch split-spoon sampler at other depths.
Sampler advanced by a 140-pound weight falling 30 inches.
Arrows show locations of sampling.

Ground Water: Not observed during drilling.
Drilling Method: 8-inch hollow stem auger, 0-13 feet
Borehole backfilled with cuttings.
Analytical Notes: No VOC constituents (except TCE which is shown on the log) were identified above 0.0002 mg/kg.
No soluble metals were identified above the STLC in soil from 3.5 and 10.7 feet.
The dectection limit for HMX and RDX is 0.001 mg/kg.
ND means none detected.
Recovery histograms show percent recovery and inferred recovery locations.
Estimates of gravels, sands, and fines are field visual estimates.



% Core recovery	Blows	RDX (mg/kg)	HMX (mg/kg)	TCE (mg/kg)
	2/2/3			
	3/3/5			0.0004
	4/9/18	0.451	ND	
NO RECORD	4/10/21			
	11/16/23/28			
	3/10/18/25	ND	ND	ND
	28/35/45			

Lithologic descriptions and/or remarks

(0-3) FILL

(0-1) SILTY GRAVEL, [GM], yellow-gray, dry, subangular to rounded pebbles to 2 inches, 20-30% silt, 5-10% sand, high estimated permeability

(1-3) CLAYEY SILT, [ML], yellow-brown, damp, soft, 10-20% clay, low estimated permeability

(3-15) TERTIARY SEDIMENTARY ROCKS

(3-12.5) CLAYEY SILT, [ML], yellow-brown, low estimated permeability
abundant randomly oriented fractures at 3-5.3 feet

stiff to very stiff and <5% very fine sand below 5.3 feet

no sand below 10 feet

(12.5-15) SILTSTONE, yellow-brown, damp, moderately indurated, 10% clay, homogeneous, no apparent bedding, low estimated permeability

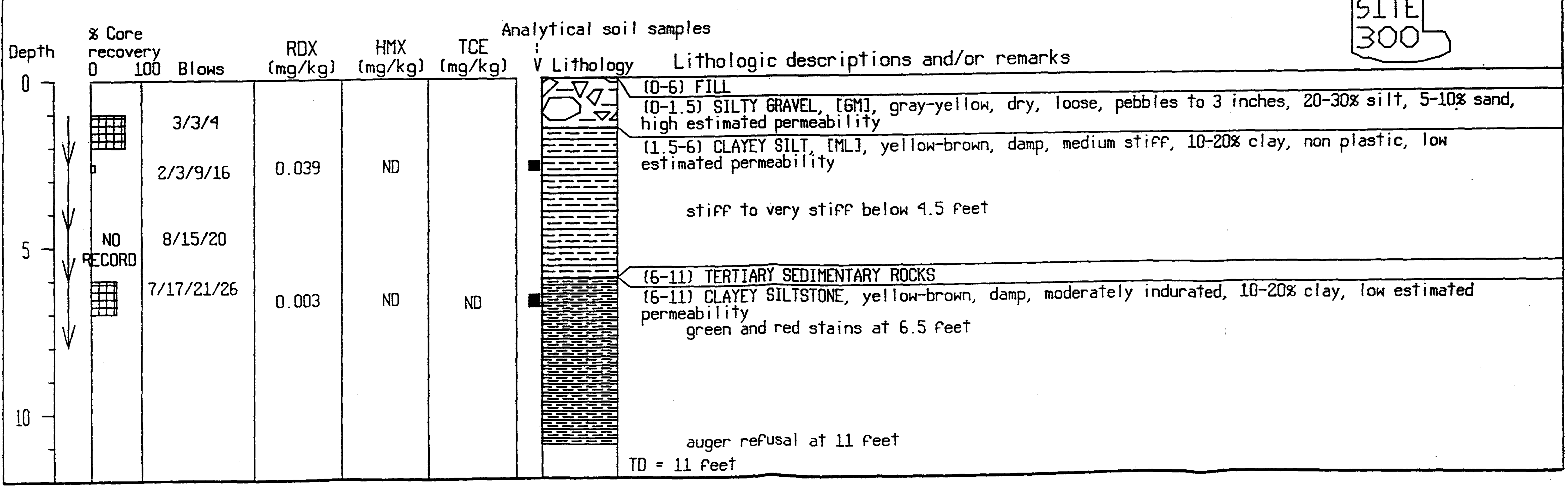
TD = 15 feet

LOG: BOREHOLE 829-12

Geologic Logging: E. Anderson, Weiss Associates, Emeryville, CA
Borehole Location: Approximately 10 feet west of Burn Pit 1,
Building 829 Area, Site 300
Coordinates: N: 417,243.6; E: 1,703,024.1
Elevation (ground): 1077.57 feet
Drilling: D. Wagster, P. C. Exploration, Inc., Roseville, CA
Date Drilled: 8/10/90
Sampling Methods: 2.5-inch I.D. split-spoon sampler at 1 and 4.5 feet; 1.4-inch split-spoon sampler at 2.5 and 6 feet. Sampler advanced by a 140-pound weight falling 30 inches. Arrows show locations of sampling.

Ground Water: Not observed during drilling.
Drilling Method: 8-inch hollow stem auger, 0-11 feet
Borehole backfilled with cuttings.
Analytical Notes: No VOC constituents were identified above 0.0002 mg/kg.
No soluble metals were identified above the STLC in soil from 6.6 feet.
The dectection limit for HMX and RDX is 0.001 mg/kg.
ND means none detected.
Recovery histograms show percent recovery and inferred recovery locations.
Estimates of gravels, sands, and fines are field visual estimates.

SITE 300



Blows	RDX (mg/kg)	HMX (mg/kg)	TCE (mg/kg)
3/3/4			
2/3/9/16	0.039	ND	
8/15/20			
7/17/21/26	0.003	ND	ND

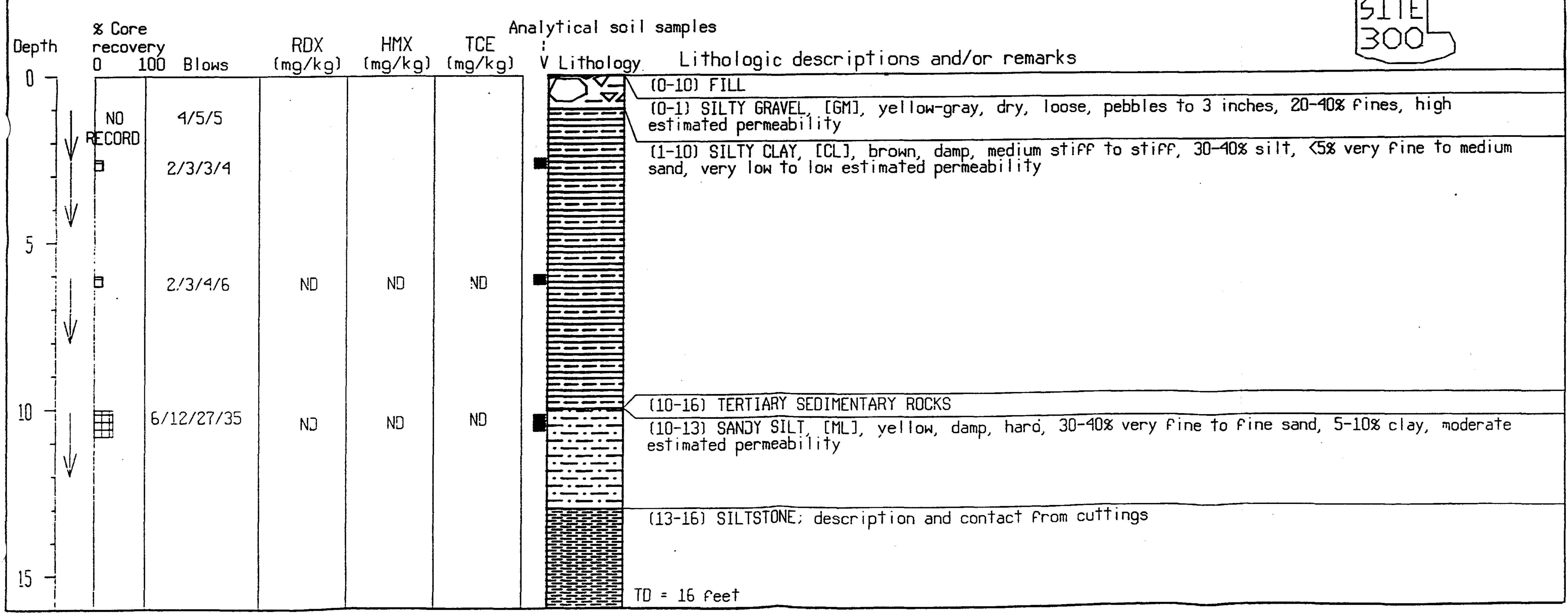
Lithologic descriptions and/or remarks

(0-6) FILL
(0-1.5) SILTY GRAVEL, (GM), gray-yellow, dry, loose, pebbles to 3 inches, 20-30% silt, 5-10% sand, high estimated permeability
(1.5-6) CLAYEY SILT, (ML), yellow-brown, damp, medium stiff, 10-20% clay, non plastic, low estimated permeability
stiff to very stiff below 4.5 feet
(6-11) TERTIARY SEDIMENTARY ROCKS
(6-11) CLAYEY SILTSTONE, yellow-brown, damp, moderately indurated, 10-20% clay, low estimated permeability
green and red stains at 6.5 feet
auger refusal at 11 feet
TD = 11 feet

LOG: BOREHOLE 829-13

Geologic Logging: E. Anderson, Weiss Associates, Emeryville, CA
Borehole Location: Approximately 10 feet south of Burn Pit 1,
Building 829 Area, Site 300
Coordinates: N: 417,211.8; E: 1,703,104.7
Elevation (ground): 1078.28 feet
Drilling: D. Wagster, P. C. Exploration, Inc., Roseville, CA
Date Drilled: 8/13/90
Sampling Methods: 2.5-inch I.D. split-spoon sampler at 1 foot;
1.4-inch split-spoon sampler at 2.5, 6, and 10 feet.
Sampler advanced by a 140-pound weight falling 30 inches.
Arrows show locations of sampling.

Ground Water: Not observed during drilling.
Drilling Method: 8-inch hollow stem auger, 0-16 feet
Borehole backfilled with cuttings.
Analytical Notes: No VOC constituents were identified above 0.0002 mg/kg.
No soluble metals were identified above the STLC in soil from
2.5 and 10.4 feet.
The dectection limit for HMX and RDX is 0.001 mg/kg.
ND means none detected.
Recovery histograms show percent recovery and inferred recovery locations.
Estimates of gravels, sands, and fines are field visual estimates.



% Core recovery	Blows	RDX (mg/kg)	HMX (mg/kg)	TCE (mg/kg)
NO RECORD	4/5/5			
	2/3/3/4			
	2/3/4/6	ND	ND	ND
	6/12/27/35	ND	ND	ND

(0-10) FILL

(0-1) SILTY GRAVEL, [GM], yellow-gray, dry, loose, pebbles to 3 inches, 20-40% fines, high estimated permeability

(1-10) SILTY CLAY, [CL], brown, damp, medium stiff to stiff, 30-40% silt, <5% very fine to medium sand, very low to low estimated permeability

(10-16) TERTIARY SEDIMENTARY ROCKS

(10-13) SANDY SILT, [ML], yellow, damp, hard, 30-40% very fine to fine sand, 5-10% clay, moderate estimated permeability

(13-16) SILTSTONE; description and contact from cuttings

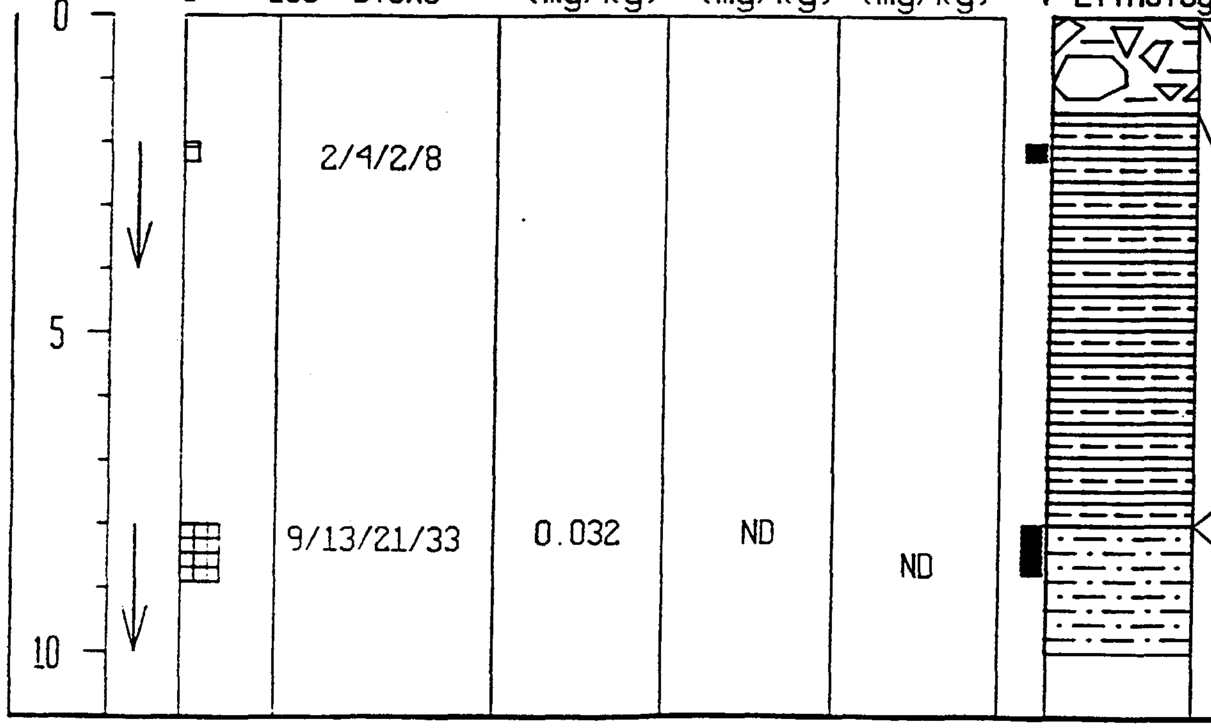
TD = 16 feet

LOG: BOREHOLE 829-14

Geologic Logging: E. Anderson, Weiss Associates, Emeryville, CA
Borehole Location: Approximately 20 feet south of Burn Pit 2,
Building 829 Area, Site 300
Coordinates: N: 417,256.1; E: 1,703,121.4
Elevation (ground): 1079.96 feet
Drilling: D. Wagster, P. C. Exploration, Inc., Roseville, CA
Date Drilled: 8/13/90
Sampling Methods: 1.4-inch I.D. split-spoon sampler.
Sampler advanced by a 140-pound weight falling 30 inches.
Arrows show locations of sampling.

Drilling Method: 8-inch hollow stem auger, 0-10 feet
Borehole backfilled with cuttings.
Ground Water: Not observed during drilling.
Analytical Notes: No VOC constituents were identified above 0.0002 mg/kg. No soluble metals were identified above the STLC in soil from 8.5 feet. No fuel hydrocarbons were identified above 1 mg/kg in soil from 2 and 8.3 feet. The dectection limit for HMX and RDX is 0.001 mg/kg. ND means none detected.
Recovery histograms show percent recovery and inferred recovery locations.
Estimates of gravels, sands, and fines are field visual estimates.

SITE 300



Depth	% Core recovery 0 100	Blows	RDX (mg/kg)	HMX (mg/kg)	TCE (mg/kg)	Analytical soil samples : V Lithology	Lithologic descriptions and/or remarks
0							(0-8) FILL
							(0-1.5) SILTY GRAVEL, [GM], yellow-gray, dry, subangular to rounded pebbles to 2 inches, 20-30% silt, 5-10% sand, high estimated permeability
		2/4/2/8					(1.5-8) SILTY CLAY, [CL], dark brown to black, damp, medium stiff to stiff, 30-40% silt, 5-10% very fine to fine sand, low to moderately plastic, very low to low estimated permeability
5							
		9/13/21/33	0.032	ND	ND		(8-10) TERTIARY SEDIMENTARY ROCKS
							(8-10) SANDY SILT, [ML], yellow-brown, damp, hard, 20-30% very fine to fine sand, 5-10% clay, non plastic, low estimated permeability
10							TD = 10 feet

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BOREHOLE / WELL CONSTRUCTION LOG

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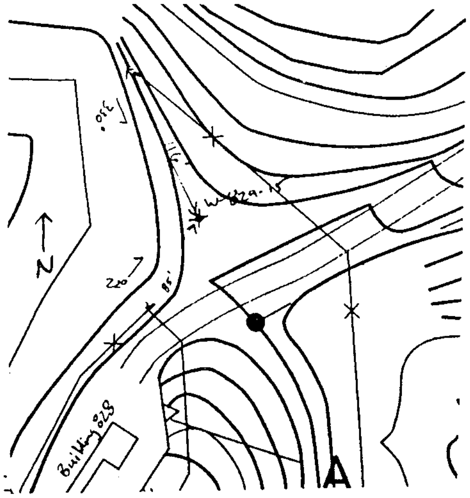
HEAD SPACE (ppm)

HOLE LOCATION



Project: HEPA	Job No: 10-0300-822
Borehole/(Well No): W-829-15	
Logged By: DJS	Edited By: ROD 1-16-95
Geophysical Logs By: Welenco see page 26 for details	☒ Yes ☐ No
Drilling Contractor: PC Exploration	Driller/Helper: Peter Shepherd / Chris Northart; Shawn Green
Drilling Method: Pilot: air mist Final: air mist	Hammer Weight: NA
Drop: NA	
Borehole Diameter (in) Pilot: 5" Final: 13" 0-80' 10" 80-399 5" 399-414	Borehole Depth (ft): 414'
Casing Depth (ft): 393.2'	
Borehole Started Time: 9:30 Date: 7/12/94	Borehole Completed Time: 1630 Date: 8/8/94
Well Construction Started Time: 13:30 Date: 8/16/94	Well Construction Completed Time: 12:00 Date: 9/8/94
Well Head Completion: above ground steel enclosure	Well Development Completed Time: 13:30 17:00 Date: 8/24/94 11/17/94 Flow Rate: 0.5-1 gpm 1-2 gpm
Water Introduced Into Borehole/Well ☒ Yes ☐ No Source: Building 843 Corp Yard	Bentonite Gel Used ☐ Yes ☒ No Product Name:

Notes / Abbreviations Used
Core scanned with geiger-muller pancake probe for γ & β, all readings match background ~ 0.1K cPM.
Ⓡ rubble zone
CLS = California Laboratory services
GTEL = Boro QA/QC lab
Hydrologic information in left column
(See Page 25 for more notes)

HYDROLOGY	Geiger/Muller	Sampler Type/Depth	Recovery Ratio: In. Driven / In. Recovered	~~Blows/6 in.~~ ROD	Circulation PL, CL	Sample Quality	Sample Identification	Laboratory / OVA / PID Results ☐ppm ☐ppb	Depth in Feet
7/12/94	BG	RC 0.5			✓ ✓ ✓	G G P	W-829-15-0.0 W-829-15-0.0 W-829-15-0.0	TTLC HE Boro	0
		RC 1.0	60/60	18/60	✓ ✓	G P	W-829-15-1.0F W-829-15-1.3F	HQD TTLC	1
ter ected 55'									2
ter ntered									3
	BG	RC 6.0	60/60	36/40					6

Well Constr.
Casing / Screen: Conductor Casing 10 3/4" OD Steel Sch 40; 4.5" ID BLANK PVC
Annulus Filler: Grout (2% bentonite); Cement

Depth in Feet: 1 2 3 4 5 6 7 8 9 10

LITHOLOGIC DESCRIPTIONS

Silty SAND (SM); grayish brown, 10YR 5/2; v. loose; dry?; 20-40% m. sand, 20-30% vf-f sand, 20% silt; 5-10% coarse sand; non plastic; HEK,

0.5

SANDSTONE; bluish gray, 5B 5/1; soft, dry? 70-80% f sand, 20-30% vf sand, < 10% silt; HEK; red sand grains common
1.4-1.8ft pebbles to 0.1' subrounded to subangular, (andesite?)

1.8

SILTSTONE, very pale brown 10YR 7/3, soft to Hard, dry? < 5% sand; LEK; black - dark grayish brown staining, randomly oriented black linear mineralization (fossilized organic fragments?)
2.0-2.4 fine bedding laminations soft sed deformation, hard
2.4-2.6 rubble zone

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

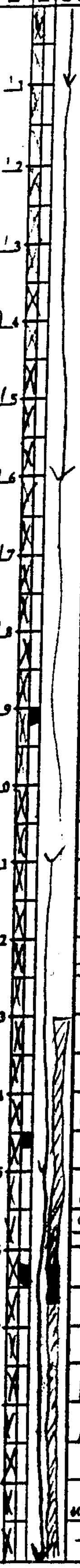
Page 2 of 26

Project:	Job No:	Borehole/Well No:
HEPA	10-300-822	W-829-15

Hydrology

Geiger/muller	Sampler Type & Depth	Recovery Ratio:	~~Blows~~ RQD	Circulation	Samp Qual	Sample ID	Lab/ OVA/PID Results	Casing/ Screen	Annulus Filler	Depth (ft)
				– –	6 6	W-829-15-10.4F W-829-15-10.6F	4E 8010			
BG	RC 11.0	60/60	36/60							11
										12
								Casing (sealed in with 2% bentonite grout)		13
										14
										15
										16
BG	RC 16	60/60	30/60							17
									Grout	18
										19
				✓	P	W-829-15-19.0F	8010		Cement	20
								PVC		21
BG	RC 21	48/48	24/48					Conductor BLANK	Bentonite	22
										23
								Steel Sch 40	2%	24
				–	6	W-829-15-24.5F	HE	10¾" OD 4.5" ID		25
BG	RC 25	60/60	54/60							26
				✓	6	W-829-15-26.3F	8010			27
										28
										29
										30

6.3'–26.7'
rc
et



— 2.6 —

Silty SANDSTONE, light yellowish brown,
2.5Y 6/3; soft, dry?, vf-f sand
60-80%, 40-20% silt, MEK,
NF / 2.7-3.6 / 80°-90° black to dark brown
stains, white mineralization (no reaction),

— 4.2 —

CLAYSTONE, light yellowish brown,
2.5Y 6/3, soft, dry?, <10% sand,
<15% silt, LEK; v. fine laminations of
black, black mineralization along
anastomosing (braided) hairline fractures roughly 70-90°
MEK 2^{nd}

— 4.5 —

Silty SANDSTONE, light yellowish brown;
2.5Y 5/3; soft, dry?, vf-f sand,
20-30% Silt, MEK, laminations to 1/2",
@ 10°,

— 5.2 —

SILTSTONE, light brownish gray, 2.5Y 6/2;
soft, dry? <10% vf sand; MEK-LEK;
very fine laminations of dark gray silt,
@ 10°
NF / 5.2-6.2 / 90° black mineralization
grades into claystone 6.0-6.2

— 6.2 —

Silty SANDSTONE interbedded with SILTSTONE,
light brownish gray, 2.5Y 6/2,
soft, dry?; vf-f sand, 15-25% silt;
MEK-HEK;
NF / 6.6-6.8 / 45° black mineralization
7.2-7.5 rip up claystone clasts
up to 1/2"
7.5-7.6 hard claystone 45

note · ■ = core wet
▨ = core ~~sat~~ damp?

WEISS ASSOCIATES

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

Page 3 of 26

Project: HEPA

Job No: 10-300-822

Borehole/Well No: W-829-15

Hydrology

1/12/94
50 blew out hole
10 no water in hole

1/12/94 →
13/94
50 no water in hole
drilled to 55'
15-blew hole dry
well dry
began injecting water
water used for remainder of drilling)
drilled down to 70'
45 blew well dry

Geiger Muller	Sampler Type & Depth	Recovery Ratio:	RQD	Circulation	Samp Qual	Sample ID	Lab/ OVA/PID Results	Casing/ Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log	
	RC	60	54										NF/7.6/20° black staining
	60	60	60							31			7.8-7.9 dark gray laminations @ 0°
													NF/7.9-9.8/30-90° open, white
										32			mineralization no reaction, black
								(sealed with 2% bentonite grout)					staining also
										33			8.3-9.4 siltstone, rubblized LEK, HEK
													common black laminated zones
										34			9.0-9.4 orange brown staining (FeO?)
													9.4-10.8 silty sandstone fine
					6	W-829-15-34.7F	HE			35			laminations, MEK-HEK
BG	RC	18	0										NF/10.6-10.8/80° white mineralization
	35	60	18										open
					6	W-829-15-36.2F	8010			36			10.8-14.4 sandy siltstone with
										37			siltstone interbeds black
													laminations in siltstone, MEK-HEK w/ LEK-MEK
										38			11.4-11.5 claystone interbed LEK
									(2% bentonite)				13.2-13.3 claystone interbed LEK
													w/ leaf fossils
										39			NF/13.5-13.8/60° open, white mineralization
								10 3/4" OD Steel Conductor Casing		40			no reaction
BG	RC	18	6					4.5" ID Sch 40 BLANK PVC					14.2-14.4 siltstone interbed
	40	60	18							41			14.4
					6	W-829-15-41.0F	8010						SANDSTONE, bluish gray, 5B 5/1,
									Cement Grout	42			soft; dry?; <10% silt, vf-f sand,
													HEK; rubblized
										43			NF/15.6/80° black stains
													15.9
										44			Sandy SILTSTONE, light brownish gray,
													2.5Y 6/2; soft; dry?; 15-40% vf-f
										45			sand, MEK-LEK 1ST HEK 2ND
BG	RC	36	18		2	W-829-15-45.5F	HE						NF/16.0/80° open, black & yellow
	45	60	36							46			brown stains, fine lamination of
													dark gray silt
													16.3-16.4 siltstone LEK
										47			NF/17.4-17.5/80° black stains
										48			17.3-17.4 fine laminations of siltstone
													@0°
													17.5-17.7 claystone clasts to 1/2"
										49			NF/17.8/45° brown staining
										50			17.8-18.0 soft sed. deformation, dark

gray laminations

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

Hydrology

Project: HEPA

Job No: 10 300-822

Borehole/Well No: W-829-15

Geiger/Muller	Sampler Type & Depth	Recovery Ratio:	RQD [redacted]	Circulation	Samp Qual	Sample ID	Lab/ OVA/PID Results	Depth (ft)
BG	RC 50	42/60	20 42		G G	W-829-15-50.0F W-829-15-50.3F	890 cls 800 cls	50
								51
								52
								53
								54
BG	RC 55	60/60	60 60		G	W-829-15-55.0F	HE cls	55
								56
								57
								58
					G	W-829-15-59.7F	800	59
BG	RC 60	60/60	60 60					60
								61
								62
					G G	W-829-15-63.2F W-829-15-63.5F	HE cls HE cls	63
								64
BG	RC 65	60/60	60 60		G	W-829-15-65.0F	Hold	65
								66
								67
								68
								69
								70

Began injecting water (at 55)

7/13/94 (at 70)

Casing/Screen: 10 3/4" OD Steel Conductor Casing; 4.5" ID Sch. 40 Blank PVC

Annulus Filler: Cement Grout (2% bentonite)

18.0

SANDSTONE, bluish gray, 5B 5/1;
soft, dry?, <15% silt, vf-f sand,
HEK

~~[illegible]~~ 19.5 19.7

SILTSTONE, light yellowish brown,
2.5Y 6.3; soft, dry?; LEK 1st, HEK
2nd, fine laminations
NF / 20.1-20.5 / 70° yellow brown -> dark brown
staining
20.5-20.8 cemented w/ CaCO3,
LEK

21.6

Silty SANDSTONE, light yellowish
brown 2.5Y 6.3 · soft, damp? ~~[illegible]~~),
15-25% silt, vf-f sand, MEK 1st, HEK 2nd; dark
gray laminations,
22.7 leaf fossils
NF / 22.4-24.5 / 80-90° open
CaCO3 mineralization
25.7-25.8 30-40% silt, dark silt
laminations, MEK-LEK
NF / 24.0-26.6 / 80°
yellow-brown staining (FeO2?)
26.6-26.9 well cemented w/
CaCO3, hard
NF/27.0-28.1 / 70° reddish brown
staining (FeO2?)
NF/28.0 / 45° light olive
brown, 2.5Y 5/4 staining
28.3-28.5 claystone clasts to 1"
NF / 28.6 / 30° dark reddish brown (5YR 3/3) - yellowish brown (10YR) stain
NF / 28.7 / 20° "
NF / 28.9 / 20° "
NF / 29.2 / 20° "
28.5-30.2 fine dark grey
laminations, xbed forsets to 1/8"
20-25% silt 26.2-26.6 moist

30.2

Sandy SILTSTONE, light brownish gray, 10YR 6/2

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Project: HEPA

Job No: 10-300-922

Borehole/Well No: W-829-15

Hydrolog

rt of day 1/14/94

0-6" of water in well drilled down to 85'

-blew out well

.25 no recharge drilled down to 100'

5 blew out hole

30 well dry

0 drilled down to 113'

0 blew hole dry

Geiser/Muller	Sampler Type & Depth	Recovery Ratio:	[redacted] RQD	Circulation	Samp Qual	Sample ID	Lab/ OVA/PID Results	Casing/ Screen	Annulus Filler	Depth (ft)
BG	RC 70	48/60	24/48							70
					6	W-829-15-71.5F	8240 CLS	Casing	bentonite	71
								Conductor	(2%	72–74
BG	RC 75	48/60	48/48		6	W-829-15-75.5F	HE CLS	Steel 10 3/4" OD	Grout (bentonite)	75
								Blank PVC 40	Cement bentonite (2%	76–79
BG	RC 80	48/60	44/48		6	W-829-15-80.3F	8240 CLS	Sch	Grout	80
								4.5" ID	Cement	81–84
BG	RC 85	60/60	60/60							85
					6	W-829-15-87.3F	HE CLS			87
										88–90

soft, dry?, 15-40% vf-f sand,

MEK 1st.

30.2-30.4 15% vf sand MEK-LEK 1st,

black laminations & xbeds - to 1/8"

NF / 30.7 / 20° black to reddish brown stains

30.4-30.9 40% vf sand, MEK

30.9-31.1 siltstone interbed

fractured MEK-HEK 2nd (Natural?)

31.1-31.9 20% vf sand MEK,

black laminations & x beds - 1/8"

31.9-32.1 naturally fractured rubble zone,

siltstone, reddish brown to olive yellow

stains,

32.1-32.9 olive yellow stains,

20-40% vf sand, bedding laminations

@ 45°

32.9-33.4 15% vf sand fine

laminations @ 10°; xbeds to 1/8"

33.4-34.9 15-30% vf sand

xbeds, bedding laminations,

——— 34.9 ———

SILTSTONE, light gray, 10YR 7/1;

soft; ~~dry~~ damp?; <10% vf sand; LEK, MEK 2nd,

rubblized, reddish brown to light

yellowish brown stains

——— 35.7 (driller) ———

Brecciated Sandy CLAYSTONE pale olive

5Y 6/3; soft; ~~dry~~ damp?; 15-30% vf-f sand,

1st LEK, 2nd HEK-MEK,

35.7-36.5 yellowish brown 10YR 4/6

to yellow 10YR 7/8 stains

NF / 40.5-41.5 / 70-90° open

stained dark reddish brown 2.5YR 2.5/4

to yellowish red 5YR 5/8

40.5- 30% vf-f sand

——— 41.5-45.0(?) ———

Clayey SANDSTONE, light olive brown

2.5Y 5/4; soft; damp?; 15-25% clay,

vf-f sand, MEK 1st, MEK-HEK 2nd.

Hydrology Geiger/Muller

RQD

Hard core

WEISS ASSOCIATES

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Project: HEPA

Job No: 10-300-822

Borehole/Well No: W-829-15

Geiger/Muller	Sampler Type & Depth	Recovery Ratio:	[redacted]	Circulation	Samp Qual	Sample ID	Lab/ OVA/PID Results	Casing/ Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log	
BG	RC 90	60/60	36 60							91			45.0-45.5 rubble zone, strong brown 7.5YR 4/6 stains (natural &
										92			drilling induced fractures) NF / 45.9-50.0 / 90° open
					6	W-829-15-92.3F	8010 CLS			93			strong brown 7.5YR 4/6 to dark reddish brown 5YR 3/2 stains
										94			—— 50.7 ——
										95			SILTSTONE, light gray 10YR 7/2; soft; dry-damp?; <15% vf sand,
BG	RC 95	60/60	60					PVC		96			LEK 1st, MEK-HEK 2nd, NF/50.3-52.0/ 90°-80°, multiple parallel
					6	W-829-96.8F	HE CLS		bentonite)	97			anastomosing fractures; open; dark reddish brown to brown stains (FeO_2?)
								BLANK		98			—— 52.0 —— Brecciated CLAYSTONE, pale olive, 5Y 5/3;
									(2%	99			soft, dry damp?, LEK 1st NF / 52.0-52.2 / 90° reddish brown to
										100			brown stains (FeO_2) open, HEK 2nd 52.2-52.8 well cemented w/
BG	RC 100	20/24	20 20					40		101			$CaCO_3$ no 2nd K, LEK 1st 52.8-53.7 well cemented w/ $CaCO_3$,
								SCH	Grout	102			rubblized w/ natural fractures black staining & reddish brown stains,
BG	RC 102	36/36	36 36		P	W-829-15-102.0F	HE CLS			103			M-H 2nd K, LEK 1st 53.7-55.2 multiple fractures @ 10°-90°
								ID	ment	104			reddish brown stains (FeO_2?) —— 55.2 ——
								4.5"	Ce	105			Sandy CLAYSTONE, light yellowish brown, 2.5Y 6/3; soft, dry, damp? 30-40%
BG	RC 105	36/60	36 36							106			vf-f sand; LEK 1st NF / 55.2-58.3 / 60-90° multiple
					6	W-829-15-106.0F	8010 CLS			107			anastomosing fractures, open, stained black and reddish brown to brownish
										108			yellow (MnO_2 & FeO_2); HE 2K; 58.5-60.0 no 2K
BG	RC 108	60/60	60 60							109			NF / 60.0-61.0 / 90°-60° multiple anastomosing fractures, open, black
										110			& reddish brown stain (FeO_2 & MnO_2) HEK 2nd

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Hydrology Muller

RQD

Headspace

Project: HEPA

Job No: [illegible]00-822

Borehole/Well No: W-829-15

14/94
3/14
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5/94
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4"
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Geisel	Sampler Type & Depth	Recovery Ratio:	[redacted]	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log	
										111			61.0 - 63.7 no 2K, some reddish brown mottling, non penetrative
										112			NF / 63.7 - 66.1 / 90°-80° open, multiple anastomosing,
					G G	W-829-15- W-829-15-	112.0F HE CLS 113.0BW			113			reddish brown stains (FeO2) MEK-HEK2
B6	RC 113	60 60	1.2 60				601 CLS			114			64.5-65.0 Silty CLAYSTONE, light yellowish
										115			brown, 2.5Y 6/3; soft, (dry) damp? <10% vf-f sand, 20-25% silt, LEK 1st;
					G	W-829-15-	115.3F 8010 CLS			116			63.7-66.2 MEK-HEK2, see above, 66.2-67.0 no 2K
								BLANK PVC	(12% bentonite)	117			67.0-67.5
										118			CLAYSTONE, light yellowish brown, 2.5Y 6/3, soft, (dry) damp? <10% silt;
B6	RC 118	60 60	4.8 60							119			LEK 1st 67.0-67.2 no 2K
					G	W-829-15-	119.4 HE CLS	4.5" ID SCH 40	Cement Grout	120			NF / 67.2-68.4 / 60-80°, open, black coating w/ metallic luster;
										121			reddish brown → yellow brown staining (FeO2?), M-HEK 2nd
										122			68.4-69.8 no 2K NF ~~/~~69.8 - 70.0 / 10° open
										123			reddish brown stains (FeO2) 70.0 - 72.4 brecciated claystone,
B6	RC 123	60 60	60 60							124			with secondary fractures throughout MEK 2nd, LEK 1st, dessication cracks
					G	W-829-15-	124.6F 8010 CLS			125			after dry 72.5
										126			Silty CLAYSTONE, light yellowish brown 2.5Y 6/3 from 72.5 - 73.3, grades into dark
										127			greenish gray 5G 4/1 73.3 to 75.5; soft; ~~dry~~ damp?; 20-30% silt, LEK 1st
										128			73.3-73.4 reddish brown filled fractures at 20°, MEK 2nd
B6	RC 128	48 60	46 48							129			NF / 73.5 / 45° open, reddish yellow-brown (FeO2) stains,
										130			NF / 75.0 - 75.8 / 45-60°, open orange brown stains (FeO2?), HEZK

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Project: HEPA

Job No: 10-300-822

Borehole/Well No: W-829-15

Hydrology

Keiser/Muller	Sampler Type & Depth	Recovery Ratio:		Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)
					G	W-829-15-130.2F	HE CLS			131
										132
										133
BG	RC 133	60/60	36/60							134
					G	W-829-15-134.4F	800 CLS			135
										136
								PVC		137
								BLANK	(2% bentonite)	138
	RC 138	0/12	0/0							139
BG	RC 139	60/60	60/60					40		140
								Sch		141
					G S	W-829-15- W-829-15-	141.0F HE CLS 141.3F HE CLS		Grout	142
								ID		143
								4.5"	Cement	144
BG	RC 144	60/60	48/60		G	W-829-15-	144.5F 800 CLS			145
										146
										147
										148
										149
BG	RC 149	48/60	24/48							150

7/18/94
7/26/94

ore down to 164' w/ 5" bit, blew hole dry

75.5-78.5 light yellowish brown
2.5Y 6/3 mottling, mottled
portions to 2" in diameter show
laminations @ 0° (oxidation reduction
zones ?)

78.0

uneven erosional contact @ 0°
Silty CLAYSTONE, greenish gray,
5GY 5/1; soft, ~~dry~~ damp?; 20-30% silt
LEK 1st, no 2K; multiple slickensides
at all angles

81.3-82.8

Sandy Claystone, greenish gray, 5GY5/1,
soft, ~~dry~~ damp?; 10-30% silt, 20-40% vf-f sand,
L-MEK 1st, MEK-HEK 2nd
80.3-80.9 multiple fractures (4-10)
10°-80°, reddish yellow staining (FeO2)
NF/81.4/10° reddish brown (FeO2) stains
81.9-82.7 light yellowish brown
~~(oxidation reduction?) zone~~
NF/82.1/45° yellow-reddish brown
stains
82.9-83.0 hard, CaCO3 cemented
zone, HCl changed greenish gray
to light ~~yellowish~~ brown
83.0-83.3 light yellow brown, 30-40% sand sf-I
83.3-83.7 greenish gray 30-40% sand sf-C
NF/83.7-84.0/80° reddish brown
stains, open MEK 2nd
NF/85.0-85.5/60° reddish brown
(FeO2) stains, CaCO3 mineralization
86.3-87.0 claystone clasts
to 2" LEK 1st
NF/86.8-87.7/45-90° open,
yellow brown stains

87.0

Clayey SANDSTONE, light gray 5Y 7/1,
soft; (?) damp?; 15-30% fines, vf-f,
sand, MEK-LEK 1st → MEK 1st

Hydrology

RQD

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Project: HEPA

Job No: 10-300822

Borehole/Well No: W-829-15

Geiger/muller	Sampler Type & Depth	Recovery Ratio:	[redacted]	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log
					G	W-829-15-150.2F	HE CLS			151		
										152		
										153		
										154		
BG	RC 154	60 60	24 60							155		
								Blank PVC	(290 bentonite)	156		
					G	W-829-15-156.7F	B010 CLS			157		
										158		
								Sch 40		159		
BG	RC 159	60 60	8 60						Grout	160		
										161		
								4.5" ID	Cement	162		
					G	W-829-15-162.4F	HE CLS			163		
										164		
BG	RC 164	60 60	12 60		G	W-829-15-164.7F	B010 CLS			165		
										166		
										167		
										168		
										169		
BG	RC 169	60 60	46 60							170		

26/94 →
27/94
o well
ry
core
own
to 184' blew out well

dry
core
down
204
blew hole dry

NF / 88.0 - 88.7 / 80°, yellow brown
(FeO2) stains.
NF / 90.9 - 91.4 / 60° reddish
brown - yellow (FeO2?) stains
91.5 - 92.3 dark gray lamination
@ 10° - 30°
NF / 92.1 / 20° Healed w/ CaCO2
mineralization
NF / 93.0 - 95.0 / 45°-90° reddish
brown, → yellow stains (FeO2?) CaCO3
mineralization, ~~yer~~
94.5
Sandy Siltstone, light yellowish
brown 2.5Y 6/3; soft, ~~dry~~ damp?
30-40% vf - f sand, LEK-MEK 1st
NF / 95.3 - 95.9 / 60° reddish brown
stains (FeO2?) MEK 2
95.9 - 96.1 siltstone
NF / 96.1 - 96.3 / 45° (FeO2)
NF / 96.3 / 30° (FeO2)
96.4-96.6 siltstone
NF / 96.3 - 97.1 / 45° (FeO2)
96.3 - 97.3 siltstone
97.3 - 97.6 20% vf-f sand
97.6 - 98.8 siltstone LEK 1st MEK 2nd
NF / 97.7 - 98.1 / 45° - 80° (FeO2?)
98.2 leaf fossils
98.0 - 98.7 reddish ~~brown~~ mottling
NF / ~~99~~.0 - 99.4 / 90° (FeO2?)
98.8 - 100.0, 20 - 30% vf-f sand
100.0 - 102.2 15% vf-f sand LEK
NF / 100.2 - 102.8 / 45° - 90° (FeO2?)
partially closed MEK 2nd
102.2 - 106.0 20-30% vf-f sand
LEK - MEK 1st
NF / 106.0-~~106.4~~/45° (FeO2?)
~~////~~ 106.5 - 106.9 ~~////~~
SILTSTONE light yellow ~~brown~~, 2.5Y6/5
soft; ~~dry~~ damp?; <10% sand; LEK 1st;
some fine laminations

Hydrology

Geiger Muller

RQD

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Project:	Job No:	Borehole/Well No:
HEPA	10-300-822	W-829-15

Geiger	Sampler Type & Depth	Recovery Ratio:	[redacted] RQD	Circulation	Samp Qual	Sample ID	Lab/ OVA/PID Results	Casing/ Screen	Annulus Filler	Depth (ft)
					G	W-829-15-170.7F	HE CLS			171
										172
										173
BG	RC 174	60/60	24/60							174
										175
					G	W-829-15-176.0F	8010 CLS	PVC		176
								Blank	(2% bentonite)	177
										178
BG	RC 179	54/60	12/54							179
										180
					G	W-829-15-181.5F	HE CLS	Sch 40	Grout	181
										182
										183
BG	RC 184	48/60	0/48					4.5" ID	Cement	184
					G	W-829-15-185.2F	BMO CLS			185
										186
										187
										188
BG	RC 189	48/60	0/48							189
										190

NF / 108.0-108.8 / 70° (FeO_2?)

open

108.8

SILTSTONE: greenish gray 5G 5/1;

soft, ~~dry~~ damp? / <15% vf sand, 15-20% clay(?)

LEK1^{V} slickens too common MEK 2$^{\Omega}$

NF / 109.8 / 10° (FeO_2?)

NF / 110.9-111.+ / 45-80°

slickensided FeO_2?

110.6-111.4 black mottling

NF / 112.0-112.9 / 80-90°

slickensided.

110.5-110.7

Silty SANDSTONE, greenish gray

5G 5/1; soft, ~~dry~~ damp, 15-30% silt

vf-f sand, MEK1^{SI},

NF / 113.4-114.2 / 70-90° partially

healed w/ $CaCO_3$

110.7-115.4 vf-f sand,

115.4-118.0 20-40% vf-f sand

20-60% med. sand

well cemented w $CaCO_3$ 5-20% silt

MEK-LEK1^{V} (due to poor sorting?)

NF / 117.4 / 20° healed w/ $CaCO_3$

NF / 117.5-118.0 / 80-90° healed w/

$CaCO_3$

118.0-119.7 60-70% med sand,

10-20% silt, 10-20 vf-f sand

5-10% coarse sand,

hard, well cemented MEK

119.9 color change to

olive brown, 2.5Y 4/3,

119.9-120.7 70-80% f sand 20% vf sand

10% silt, MEK-HEK

120.7-120.9 80% vf sand, 20% silt

MEK-HEK

121.0

Brecciated SILTSTONE: light yellowish

brown, 2.5Y 6/3, ~~dry~~ soft, <15% vf

-f sand, damp?

Hydrology

KQC

WEISS ASSOCIATES

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Head 6.080

Project:	Job No:	Borehole/Well No:
HEPA	10-300-922	W-829-15

Geiger/Muller	Sampler Type & Depth	Recovery Ratio:	[redacted]	Circulation	Samp Qual	Sample ID	Lab/ OVA/PID Results	Casing/ Screen	Annulus Filler	Depth (ft)
					6	W-829.15-	190.3F HE CLS			191
										192
										193
										194
SG	RC 194	12/60	0 12		G	W-829-15-	194.7F			195
							8010 CLS			196
								BLANK PVC	(29' bentonite)	197
										198
										199
SG	RC 199	12/60	0 12							200
								4.5'' ID Sch 40	Cement Grout	201
										202
										203
										204
SG	RC 204	30/60	0 30							205
										206
					G	W-829-15-	206.2F 8010 CLS			207
										208
										209
SG	RC 209	48/60	12 48							210

28/94
o -2'' f water in hole
core down to 224
blew hole dry
3' of water in hole
ok
ater
ample

LEK1st HEK2nd

121.6 - 121.8

CLAYSTONE, greenish gray, 5GY 6/1,
~~dry~~, soft, <15% vf sand,
LE1K desiccation cracks, ~~abundant~~ very
slickensides, MEZK

122.5 - 1230

Silty CLAYSTONE, greenish gray,
5GY 6/1, soft, ~~dry~~ damp, 20-30% silt,
MEK1st,
123.2 - 123.3 FeO2?) staining
124.9 - 125.2 greenish tint
126.6 - 127.2 light yellowish brown
10% f-vf sand, MEK1st
129.6 - 130.2 laminations (bedding
planes?)

130.2

SANDSTONE, light yellowish brown,
2.5Y 6/3, soft, ~~dry~~ damp?; vf-f sand,
M-HEK

130.9 - 131.2

CLAYSTONE dark greenish
gray ~~5GY~~ 5GY4/1 to Black 2.5Y 2/0,
soft, ~~dry~~ damp?; LEIK; M-HEZK
131.4-131.5 laminations of silt.
NF/ 131.5 - 131.9 / 90° (FeO2?)
staining, open
133.4 - 134.4 10-20% vf-f sand,

134.9

SILTSTONE, white 10YR 8/2,
soft, ~~dry~~ damp?, 10-20% vf sand,
MEK-LEK1st
CIF/ 135.0-135.6/0°, 4 horizontal fractures
defining 0.1' sections
NF/ 136.0 - 137.8/ 70-90°
(MnO2 & FeO2?) staining
136.0 - 138.0 $CaCO_3$ lenses at
random orientations to 0.1'
139.0 - 140.6 worm burrows?) defined

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

Project: HEPA

Job No: 10-300-822

Borehole/Well No: W-829-15

Hydrology

core down to 234.0'

:10 blew hole dry

6:20 1' of water in hole

Geiser/Muller	Sampler Type & Depth	Recovery Ratio:	[redacted]	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)
					G	W-829-15-210.0F	HE CLS			211
										212
										213
										214
BG	RC 214	60/60	100 100							215
										216
								PVC		217
					G	W-829-15-217.0F	8010 CLS	BLANK	bentonite)	218
										219
BG	RC 219	40/60	48					40	(2%	220
					G	W-829-15-219.9F	HE CLS	Sch		221
									Grout	222
								ID	Cement	223
								4.5"		224
BG	RC 224	60/60	60 100		F G	W-829-15-224.0BW W-829-15-226.0F	601 CLS 8010 CLS			225
										226
										227
										228
										229
BG	RC 229	60/60	57 100		G	W-829-15-229.7F	HE CLS			230

by white mineralization

NF / 139.0 - 139.4 / 90° FeO2 (and MnO2?) stains

NF / 139.5 / 0°-15° FeO2 - MnO2? stains

NF / 140.1 / 20° FeO2 - MnO2 stains

NF / 140.4 - 140.9 / 30°-90° FeO2 & MnO2 stains

141.0 - 141.6

Silty SANDSTONE, white 10YR 8/2

soft, ~~dry~~ (damp?) 20-40% silt, vf-f sand,

ME1K, M-4E2K

141.6 - 142.6 rare (<5%) FeO2

rich claystone clasts to 1", @ 0°-10°

NF / 142.5 / 30° FeO2 & MnO2 stains

NF / 143.7 / 45° FeO2 & MnO2 stains

NF / 144.0 - 144.4 / 80-90° FeO2 & MnO2 stains

144.4' - 144.6 - rubble zone, (coring induced?)

NF / 144.9 / 20° FeO2 & MnO2 stains

CIF / 145.0 - 145.3 / 90°

NF / 145.3 / 20° FeO2 & MnO2 stains

146.3 siltstone clast, laminations of sand at 0°, 1" x 3"

CIF / 146.5 / 0°

CIF / 147.0 / 0°

147.5

SILTSTONE, light gray 5Y 7/1;

soft, ~~dry~~ (damp?). <15 % sand;

M-LE1K; laminations at 0-10°

NF / 148.1 / 10° FeO2 stains

NF / 148.5 / 20° no stains

NF / 148.6 / 20° (FeO2 & MnO2) stains

NF / 149.0 - 149.7 / 45-90° MnO2 stains

149.7

irregular erosional contact

SANDSTONE, gray 5Y6/1, soft, (Moist?). <15 silt, vf-med sand, HEK1P

150.2 - 150.9 coring induced rubble zone

Hydrology Aull

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Project:	Job No:	Borehole/Well No:
HEPA	10-300-822	W-829-15

Geiger	Sampler Type & Depth	Recovery Ratio	[redacted]	Circulation	Samp Qual	Sample ID	Lab/ OVA/PID Results	Casing/ Screen	Annulus Filler	Depth (ft)
										231
										232
										233
BG	RC 234	60 60	60 60		6	W-829-15-234.0 BW	601 CLS			234
					F	W-829-15-235.0F	8010 CLS			235
								Blank PVC	(2% bentonite)	236
										237
										238
BG	RC 239	48 60	24 48					Sch 40	Grout	239
					6	W-829-15-241.0F	HE CLS	4.5" ID	Cement	240
										241
										242
										243
BG	RC 244	36 60	0 36							244
					G	W-829-15-245.5F	8010 CLS			245
										246
										247
										248
BG	RC 249	54 60	 54		6	W-829-15-249.1F	HE CLS			249
										260

Headspace

150.7-150.8 CaCO₃ Cement in half of Core, NF/150.9/45° (FeO₂ & MnO₂ Stains

151.0

SILTSTONE, light gray 2.5Y 7/2; soft; (~~dry?~~) damp? <15% sand, MEK 1st thin sandy (~20%?) laminations at 0°-10°

151.5-152.0 sandstone interbed, M-HEK

NF/152.0-152.2/ 70-90° FeO₂ stains

NF/152.4-153.0/70° (FeO₂ & MnO₂) Stains

154.3

Sandy SILTSTONE, light gray 2.5Y 7/2; soft, damp ~~dry?~~; 15%-50% silt, MEK 1st

NF/155.2/80° MnO₂ stains

155.6-155.9

SANDSTONE, bluish gray 5B 5/1; soft, (~~dry?~~) damp?; <15% silt, 80-90 f sand 10-20% m. sand, HEK

CIF/156.2/20°

156.7-157.9 coring induced rubble zone, sections from 1" - 3"

157.9 - 159.0 M-HEK, silty sandstone interbed ~20% silt w/ 4 parallel coring induced fractures @ 45° from 157.9-158.3

159.7-160.8 (coring induced?) rubble Zone

162.4- 163.0 ~~?~~0% med. sand, 60% f sand

163.0 - 164.0 70% med sand 30% f sand, H-VHEK

164.3-164.4 siltstone interbed

HFZ / 164.4 -167.9/ 1"-3"

168.0

Sandy SILTSTONE, light brownish gray, 2.5Y 6/2, soft, dry damp?, 20-30% vf-f sand

28/94 → 11/94

- water @ 216.0' (bgs)

et water sample

core down to 254'

blew hole dry

" @ 222' (bgs)

Note: Blister in casing occured @ 250' during grouting of annular space. See page 26 for additional details.

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

Hydrology

RS

Project: HEPA

Job No: 10-300-322

Borehole/Well No: W-829-15

Geologist/Initials	Sampler Type & Depth	Recovery Ratio	~~Stains~~	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)
										251
										252
										253
										254
BG	RC 254	60/60	48/60							255
					G	W-829-15-255.3F	8010 CLS			256
										257
								PVC	bentonite)	258
								Blank	(2%	259
BG	RC 259	60/60	60/60							260
					G G	W-829-15-(2603)-260.6F W-829-15-(2604)-DUP-260.6F	HE: CLS 8010 GTEL			261
								Sch 40	Grout	262
										263
								4.5" ID	Cement	264
BG	RC 264	60/60	40/60							265
					G	W-829-15-265.0F	8010 CLS			266
										267
										268
										269
BG	RC 269	60/60	40/60							270

MEK,
NF / 168.1 - 168.6 / 60-90° FeO_2 stains
168.6
SILTSTONE, light gray, 2.5Y 7/2,
soft ~~dry~~ damp; <15% vf sand, MEK
fine dark grained laminations at contact
NF / 168.7 - 169.0 / 80° MnO_2 & FeO_2
stains
168.7 - 169.0 finely laminated
NF / 169.0 - 170.8 / 80°-90° FeO_2 & MnO_2
stains closed with $CaCO_3$ 170.0 - 170.8
171.0 leaf fossil
NF / 171.3 / 20° closed w/ $CaCO_3$
(MnO_2) stains
~~171.6 - 171.8~~
Silty SANDSTONE, bluish gray, 5B 5/1,
soft, ~~(dry?)~~ damp 20-30% vf sand,
MEK 1 & MEK 2nd,
NF / 171.5 - 172.6 / 30-70° (MnO_2)
stains
NF / 172.7 - 173.3 / 80° (MnO_2) stains
173.7
SILTSTONE light gray 2.5Y 7/2; soft,
~~(dry?)~~ damp <15% sand, 20-40% clay (?);
CEK 1st, M-HEK 2nd
NF / 174.0 - 174.5 / 0-10° (FeO_2) stains
multiple horizontal partially closed
174.7 - 174.9 no clay
175.4
SANDSTONE, bluish gray 5B 5/1,
soft, damp (dry?), <15% silt, 80-90% fine
sand 10-20% ~~med sand~~ HEK 1st
CIF / 176.5 / 45°
176.8 - 177.6 coring induced fracture
zone, sharp contact @ 10°
177.6
SILTSTONE, light gray, 2.5Y 7/2,
soft ~~damp~~ (dry?) ~15% vf sand;
MEK 1st M-HEK 2nd
NF / 177.6 - 178.5 / 90° (MnO_2 & FeO_2)
Stains

3/1/94 → 8/2/94
water
00 @ 233.5 (bgs)
5 - blew out hole
15 - 247.8 bgs
30 - 247.7' (bgs)
20 core down to 279'
dry
to blow
out marker bed
0 1' of water in hole
xpect recharge rate of 1' per hour,
lay from marker bed could be preventing recharge)
core down to 294
5 blew
d
"

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Hydrology Mulle

RQD

Head 5/1/90

Project:	Job No:	Borehole/Well No:
HEPA	10-300-822	W-829-15

Leiser	Sampler Type & Depth	Recovery Ratio	[redacted]	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log	
										271			178.1 - 178.5 rubble zone, MnO$_2$ ' 3 FeO$_2$ stains
										272			178.5 - 179.0 hairline anastomosing fractures, filled with FeO$_2$ 3 MnO$_2$, no sand 100% silt
										273			NF / 179.0 - 180.2 / 70°-80° MnO$_2$ 3 FeO$_2$ stains
					G F	W-829-15-(273.4)-273.7F W-829-15-(273.7)-Dup-273.7F	HE CLS			274			NF / 180.2 - 181.0 / 70° slickensided
86	RC 274	60/60	48/60				HE LAB222			275			NF / 180.6 - 181.2 / 70° CaCO$_3$ xtals, open, MnO$_2$ stains
										276			181.5
					G	W-829-15-276.8F			(2% bentonite)	277			SANDSTONE, bluish gray, 5B 5/1, soft, (damp ~~dry~~?), 80-90% vf sand
							B010 CLS	PVC		278			10-20% f sand, MEK 1st, HEK 2nd 181.5 - rubble zone, (MnO$_2$ 3
								Blank		279			FeO$_2$?) stains, 183.5 - 184.0
86	RC 279	54/60	24/54							280			SILTSTONE, light gray 2.5Y 7/2; soft, (moist ?); <5% vf sand
					G	W-829-15-280.4F	HE CLS	40	Grout	281			LEK 1st, MEK 2nd, 184.0 - 184.4 rubble zone, (MnO$_2$ 3
								Sch	Cement	282			FeO$_2$) stains 184.4
								ID		283			SANDSTONE, bluish gray 5B5/1, soft (moist ?); 80-90% vf sand,
								4.5"		284			10-20% f sand, HEK; reduced to rubble by coring
86	RC 284	54/60	0/54		G	W-829-15-284.3F				285			185.5 SILTSTONE light gray 2.5Y 7/2; soft, (damp ~~dry~~?); <15% sand; MEK 1st,
							B010 CLS			286			M-HEK 2nd 185.5 - rubble zone,
										287			MnO$_2$ 3 FeO$_2$ stains 189.0
										288			
										289			SANDSTONE, bluish gray, 5B5/1, soft; (damp ~~moist~~?); <15% fines, 100%
86	RC 289	54/60	0/54							290			vf-f sand; HEK; HFZ / 189.0 - 190.7 / 1"-3" @ 0°-45°

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Hydrology

Project	Job No	Borehole/Well No:
HEPA	10-300-822	W-829-15

8/2/94

8/3/94
..10 1' of water in hole
clay preventing recharge?)
45 core down to 324'
5 blew hole dry
45 ..ter
.. 13'
..gs)
..0 core down to 344'
20 blew out hole
tried successfully get
..ter sample

Geiser/Muller	Sampler Type & Depth	Recovery Ratio	RQD	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)
					G	W-829-15-290.0F	HE CLS			290
										291
										292
										293
										294
36	RC 294	24/60	0 24							295
					G	W-829-15-295.0F	8010 CLS			296
								Blank PVC	bentonite (2%	297
										298
										299
36	RC 299	24/60	12 24		G	W-829-15-299.2F	HE CLS	Sch 40	Grout	300
										301
										302
								4.5" ID	Cement	303
										304
36	RC 304	60/60	54 60		G	W-829-15-304.2F	8010 CLS			305
										306
										307
										308
										309
36	RC 309	60/60	60 60		G	W-829-15-309.0F	HE CLS			310

190.7-191.1 silty SANDSTONE interbed,
15-25% silt bedding planes visible
@ 45°
NF / 190.8 - 191.1 / 70° FeO_2 & MnO_2
staining
191.7
SILTSTONE; light gray 2.5Y 7/2;
soft, (?); 15-30% vf sand,
MEK; bedding laminations @ 45°
191.9-192.0 sandstone interbed,
MEK vf-f sand
NF / 192.0 - 192.7 / 0-70° multiple
fractures, closed, (MnO, & FeO_2) Stains
192.7-193.0 sandstone interbed,
MEK, 100% vf-f sand
194.0-194.9 sandstone
194.9-199.0 no recovery
199.0-200.0 siltstone, rubblized,
(MnO_2 & FeO_2) stains
200.0-204.0 no recovery
204.0-206.5 rubblized siltstone w/
~10% slickensided claystone surfaces,
very fine planar lamination of alternating
clay/silt grains, MnO_2 & FeO_2 stains
common, LEIK, HE2K
206.5-209 no recovery
209.0-210.0 siltstone rubblized,
$CaCO_3$, (MnO_2 & FeO_2) stains on natural
fracture faces, HE2K,
210.0-212.1 siltstone & sandy siltstone
xbedded w/ 1/2" forsets,
NF / 210.3 / 20° (FeO_2 & MnO_2)
stains
NF / 210.7 / 20° (FeO_2 & MnO_2) stains
NF / 211.1 / 20° MnO_2) stains
212.1-213.0 rubblized siltstone (FeO_2
& MnO_2) stains
214.0-217.0 siltstone w/ claystone
laminations, LEIK M-HE2K
NF / 214.0 - 216.3 / 70-90° anastomosing

Hydrology

Geiger muller

EQ

Head space

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Project: HEPA

Job No: 10-300-822

Borehole/Well No: W-829-15

Geiger	Sampler Type & Depth	Recovery Ratio	[illegible]	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log	
										311	X		open hairline fractures, extensive MnO2 & FeO2 stains
										312	X		215.0 leaf fossils sharp color change @ 216.4 @ 45° from
										313	X		light gray 2.5Y 7/2 → bluish gray 5B 6/1
										314	X		216.4 - 217.0 Silty SANDSTONE, greenish gray 5GY 6/1
bg	RC 314	60 60	60 60							315	X		soft, damp?) 20-30% silt, 10% clay; 10-30 vf-f sand, MEK 1st, no 2K
								PVC	)	316	X		NF / 216.7 / 45° FeO2 stains NF / 217.1 / 0° FeO2 mineralization healed
							8010 CLS		bentonite	317	X		healed 219.0 - 222.2 no clay, M-HEK 1st,
					6 6	W-829-15-(317.5)-317.3F W-829-15-(317.3)-DUP-317.3F	8010 CLS	Blank		318	X		no 2K CIF / 220.4 / 10°
									(2%	319	X		CIF / 220.9 / 45° 222.0
bg	RC 319	60 60	48 60					40		320	X		Silty SANDSTONE to Sandy SILTSTONE, bluish gray, 5B 5/1, soft, (moist?),
					6	W-829-15-320.8F HE CLS		Sch	Grout	321	X		30-60% silt, 40-70% vf-f sand ME1K, no 2K,
								'		322	X		NF / 224.0 / 45° grayish green 5G 5/2 mineralization
								ID	Cement	323	X		NF / 227.2 / 20° healed w/ CaCO3 inside of core damp
								4.5"		324	X		NF / 229.5 / 20° healed w/ CaCO3 230.5
bg	RC 324	60 60	0 60							325	X		SILTSTONE, bluish gray 5B5/1, soft, damp?), <15 sand, ME1K,
					6	W-829-15-325.7				326	X		NF / 229.5 - 230.8 / 90° healed w/ CaCO3
							8010 CLS			327	X		232.9 Sandy SILTSTONE, bluish gray 5B5/1,
										328	X		soft, dry?, 0-20% m sand 15-30% vf-f sand, ME1K,
										329	X		232.9 - 234.6 20% m sand, 20-25% vf-f sand
bg	RC 329	60 60	24 60		6	W-829-15-329.0F	HE CLS			330	X		234.6 - 235.0 no med. sand, 10% clay, LEK 235.0

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Hydrology mullc

RG

Head space

Project: HEQA	Job No: 10-300-822	Borehole/Well No: W-829-15

Geiger	Sampler Type & Depth	Recovery Ratio:	[redacted]	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log	
										331			Silty SANDSTONE bluish gray, 5B 5/1, soft, moist?); 20-30% silt, vf-f sand,
										332			ME1K ~~no~~ 2K 236.5-236.8 finely laminated @ 45° ME1K
										333			236.8-237.3 siltstone M-LEK1/2I 237.3-242.5 silty SANDSTONE, 20-30
										334			% silt, vf-f sand ~~—~~ MEK NF/237.0-238.3/ 70-90° open,
06	RC 334	60/60	24/60		G	W-829-15-	334.6F 810 CLS			335			slickensided HFZ/240.3-242.5/ 1-2" sections
										336			242.5
								4.5' ID Sch 40 Blank PVC	Cement Grout (2% bentonite)	337			Brecciated CLAYSTONE, dark greenish gray, 5G 4/1, soft, (moist?); <15 sand;
										338			LE1K, ME2K;
										339			246.0 Silty CLAYSTONE grading into Sandy Claystone
36	RC 339	36/60	32/36		G	W-829-15-3	39.0F 810 CLS			340			5G 6/1, soft, ~~dry~~ damp?; 10-30% silt; 10-40% vf-f sand; LE1K, ME2K,
										341			slickensides common HFZ/246.0-250.5/ 1"-2"
										342			250.0-251.5 - sandy claystone, 40% f sand, L-MEK
										343			251.5 Sandy SILTSTONE to Silty SANDSTONE;
										344			light gray, 2.5Y 7/2; soft, ~~dry~~ damp?; 15-60% vf-f sand, 15-80% silt, M-LE1K,
36	RC 344	36/60	0/36		G	W-829-15-	344.0BW 601 CLS			345			251.5-252.4 sandy siltstone, lamination @ 10°, 20% silt, 30% vf-f sand
					G	W-829-15-3	45.5F HE CLS			346			NF/252.0-252.9/ 70° healed w/ $CaCO_3$,
										347			252.4-252.7 silty sandstone 60% f sand 40% silt
										348			252.7-253.7 sandy siltstone 90% silt, 10% vf sand, LEK
										349			253.7-254.0 silty sandstone MEK 254.0-254.8 sandy SILTSTONE, M-LEK
36	RC 349	60/60	48/60							350			some soft sed deformation, fine laminations,

3/3/94

8/4/94 →

50 water @ 327.2' (bgs)

10 core down to 364'

:45 blew hole 1

o ~re ^ 379'

o blew hole dry

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Hydrology
Geiger / Miller

Project:	Job No:	Borehole/Well No:
HEPA	10-300-822	W-829-15

Headspace (ppm)

Geiger	Sampler Type & Depth	Recovery Ratio	RR	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)
							8010 CLS			352
					G G	W-829-15-(352.4)-352.7 W-829-15-(352.7)-DUP-352.7F	8010 CLS			353
BG	RC 354	60/60	60/60							355
					G	W-829-15-356.7F	HE CLS	PVC Blank	bentonite (2%)	357
BG	RC 359	60/60	60/60		G	W-829-15-359.0F	8010 CLS	Sch 40	Grout	360
								4.5" ID	Cement	364
BG	RC 364	60/60	50/60		G	W-829-15-364.8F	8010 CLS			365
							HE CLS			369
BG	RC 369	60/60	18/60		G G	W-829-15-(369.?)-369.8F W-829-15-(369.?)-DUP-369.8F	HE CLS			370

254.8-255.4 siltstone LEK
255.4-257.0 silty SANDSTONE,
finely laminated & crossbedded
MEK, bottom contact @ 45° (257.0-257.
——— 257.0 ———
silty SANDSTONE, light gray, 2.5Y 7/2
soft (moist?); 20-50% silt, 0-40% m. sand 30-80%
vf-f sand 10% silt, M-HEK
258.5 258.6 siltstone LEK
258.6-262.8 silty sandstone
20% silt, 70% vf-f sand
262.8-264.8 silty sandstone
20% silt 40-50% f sand 30-40%
m sand MEK
NF/264.2-264.6/60° MnO2 stains
with parallel healed fractures anastomosing
NF/264.6-265.9/70-90°
multiple anastomosing subparallel
fractures, healed
NF/265.9-266.5/80° MnO2 stains
Ⓡ/266.5-267.5/(MnO2 & FeO2)
stains
262.8-268.7 silty SANDSTONE
20-30% silt, 70-80% vf-f sand MEK,
M-HEK
NF/268.1/10° MnO2 stains
NF/268.8/10° healed w/ CaCO3
268.7-271.1 sandy SILTSTONE, MEK, 10-20% med
sand 20-30% vf-f sand, 50-70% silt
NF/269.4/30° MnO2 stains
NF/270.7/45° FeO2 & MnO2 stains
~~+++++++~~ 271.1-271.4 ~~+++++++++~~
SANDSTONE bluish gray; 5B 5/1,
soft, (wet?); 50-70% med sand, 20-30
f sand 20-30% vf sand; 10-15% coarse,
HEK,
274.5-276.3 sandy SILTSTONE,
light gray 2.5Y 7/2, MEK,
277.4-278.3 sandy SILTSTONE, light gray
2.5Y 7/2, MEK

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Hydrology

RQD

Project:	Job No:	Borehole/Well No:
HEPA	10-300-822	W-829-15

Geiger muller	Sampler Type & Depth	Recovery Ratio	[redacted]	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results
BG	RC 374	60/60	60/60				
					6	W-829-15-378.7F	BAO CLS
BG	RC 379	60/60	60/60		6	W-829-15-379.0BW	601 CLS
					6	W-829-15-379.0F	HE CLS
BG	RC 384	49/60	24/49		6	W-829-15-384.0F	BAO CLS
BG	RC 389	36/60	0/36		6	W-829-15-389.0F	HE CLS

Casing/Screen: Blank PVC Sch 40 4.5" ID; 382.2'; PVC Slotted 0.02" Sch 40 4.5" ID

Annulus Filler: 2% bentonite; Cement Grout; Bentonite Seal; #0/2 sand; Lonestar Sand #3

Depth (ft): 37_1 37_2 37_3 37_4 37_5 37_6 37_7 37_8 37_9 38_0 38_1 38_2 38_3 38_4 38_5 38_6 38_7 38_8 38_9 39_0

NF / 278.0 / 70° healed w/ CaCO3
FeO2 staining
279.3-279.7 silty SANDSTONE,
MEK, 20-30% silt
280.2-280.4 silty sandstone MEK
MEK 20-30% silt
281.3-281.5 silty sandstone, MEK,
20-30% silt

HFZ / 281.5-282.8 / 2" (drilling
induced ?)
282.8-283.2 silty sandstone
MEK 20-30% silt
NF / 283.1 / 45° FeO2 & MnO2
stains very dark, open
283.3-284.0 sandstone 50-70% m sand
30-40% f sand 20-30% vf sand
multiple healed fractures w/ FeO2
stains 10°-20°
284.0-289.0 50-70% m sand
50-50% f sand, M-MEK, (Quartz grains FeO2 stain
HFZ / 284.0-289.0 / 3"-4"
rare claystone clasts.
HFZ / 289.0-294.0 / 3"-4", 50-70% m sand M-MEK
290.7-291.2 claystone laminations
to 1/8" thick @ 0°, (bedding?)
291.9-292.3 claystone laminations
to 1/4" @ 0° (bedding?)
292.7-293.0 silty sandstone
interbed, w/ 1/4" subrounded siltstone
clast
HFZ / 294.0-296.0 / 1"-2"
294.4-294.5 siltstone clast < 5" dia.
FeO2 stains
295.4-295.6 10% andesite pebbles,
subrounded 1/8"-1" in diameter, ~~angular~~
HFZ / 299.0-300.0 / 1"-2" andesite
pebbles, (see above)
303.0 (drilling?)
SILTSTONE,

3/4/94
8' ...
...ter
@ 338.4' (bgs)
took bailed sample
...0 Core down to 399'
...0 blew hole dry
...00 water @ 336.2' (bgs)
...20 Core down to 414 (total depth)
...0 blew hole dry.
30 ...
...nd
...sing @
' per 45 seconds
...ook bailed water sample

Hydrology RQD

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Headspace

Project: 4EPA

Job No: 10-300-822

Borehole/Well No: W-829-15

beiger/muller	Sampler Type & Depth	Recovery Ratio	[redacted]	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)
									#3 SAND	391
										392
										393
B6	RC 394	60/60	42/60		G	W-829-15-394.0F	8010 CLS			394
									Slough	395
										396
										397
										398
SG	RC 399	48/60	48/48		G	W-829-15-399.0F	HE CLS			399
										400
										401
										402
										403
SG	RC 404	60/60	60/60		G	W-829-15-404.8F	8010 CLS		Bentonite Seal	404
										405
										406
										407
										408
SG	RC 409	60/60	48/60							409
										410

303.0 - 304.2 light brownish gray
2.5Y 6/2
304.2 - 305.5 gray 2.5Y N5/0
305.5 - 309.0 dark greenish gray 5GY 4/1
309.0 - 314.8 bluish gray 5B 5/1
soft (damp?); <15% of sand, LEIK, NO2K
303.0 - 304.2 multiple hairline ~~anastomosing~~ braided
fractures, healed, stained w/ FeO2
NF/304.3 - 304.9 / 70-90° slickensided,
healed w/ Pyrite mineralization
305.0 - 305.5 rubble zone, striated surfaces @ 0-45°
305.5 - 309.0 black mottling
NF/309.3 - 310.2 / 70-90° slickensided
315 - 317.9 vertical anastomosing slickensides, closed
314.2 - 314.4
Silty SANDSTONE, bluish gray 5B5/1,
soft (damp?), 20-30% silt, 70-80% vf-f
sand, MEK, very uniform
NF/316.8 / 20° healed w/ $CaCO_3$
320.0 color change to light yellowish
brown 2.5Y 6/4
320.8
(erosional) contact @ 0°
320.6 - 320.8 grades from silty sandstone
to siltstone
SANDSTONE, bluish gray 5B 5/1,
soft (wet?); 50-70% m sand,
30-50% f sand friable, HEK.
NF/321.6/60° healed
322.8 - 322.9 sandy siltstone interbed,
light yellowish brown 2.5Y 6/2
HFZ / 324.0 - 330.0 / 1"-4" 10% coarse
sand rare andesite pebbles
330.0
Sandy SILTSTONE, greenish gray 5GY 5/1,
soft (wet?), 20-30% vf-f sand,
MEK 1E
NF/ 330.5 - 331.2 / 70-90° slickensided
striations perpendicular to long axis of
core

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Hydrology

RQD

Project:	Job No:	Borehole/Well No:
HEPA	10-300-822	W-829-15

Geiger/mull	Sampler Type & Depth	Recovery Ratio	[redacted]	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log
										411		
					6	W-829-15-411.5F	HE OLS		Bentonite seal	412		
										413		
					G	W-829-15-414.03W	60 CLS		TD	414		
										415		
										416		
										417		
										418		
										419		
										420		
										421		
										422		
										423		
										424		
										425		
										426		
										427		
										428		
										429		
										430		

331.4

Brecciated CLAYSTONE, dark greenish
gray 5G 4/1, soft (wet?);
10% silt, LE1K, HE2K,
abundant slickensides

334.5

Sandy SILTSTONE, greenish gray
5GY 5/1, soft moist?). 20-30% vf-f
sand, MEIK, greenish gray claystone
stringers to 1/4" thick,
NF / 336.0 / 10° CaCO3 healed
336.9 Color change from
greenish gray to gray 5Y 6/1,
CaCO3 at interface @ 20°

341.8 ?)

SANDSTONE, dark blue gray 5B 4/1,
soft wet 70-80% m. sand,
20-30% vf-f sand, HEK,
lower contact irregular, erosional

346.5

SILTSTONE, greenish gray 5GY 6/1,
soft, moist?). 10% vf sand, MEKF
NF / 346.5 - / 90° slickensided,
shallow parallel to core axis
NF / 349.0 - 349.8 / 80-90° open Some
CaCO3

34[illegible]

Silty SANDSTONE, greenish gray
5GY 6/1, soft (moist?). 20-40%
silt, 60-80% vf sand, MEK - HEK
354.0 - 355.5 40% silt MEK
355.5 - 357.9 20% silt M-HEK
OF / 356.0 / 45°
CIF / 356.4 / 70°

359.0

SANDSTONE, bluish gray 5B 5/1
soft, moist; 40-60% m sand, 40-60%
f sand, HEK

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Headspace

Sampler Type & Depth	Recovery Ratio:	Blows/6 In	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log	Project: HEPA	Job No: 10-300-827	Borehole/Well No: W-829-15

361.3

[illegible] SANDSTONE, bluish gray,

5B 5/1 [illegible]

[illegible] - 80% f sand MEK

[illegible]1.3

SANDSTONE [illegible] 5B 5/1

[illegible] 20-30% m sand

[illegible]-70% [illegible] sand MEK

[illegible]

SANDSTONE, bluish gray 5B 5/1

[illegible] 20-30% [illegible]

[illegible] sand M-MEK

367.3

SILTSTONE, bluish gray 5B 5/1, soft, moist, 20-30% vf sand, MEK

NF/367.8 - 368.5/70° slickensides striations perpendicular to core axis

NF/368.6 - 369.0 / 90° slick, striation perpendicular to core axis

CIF/369.0 - 370.7/90° multiple (2-4) vertical fractures

370.0 - 380.0 fine laminations at 0-10° (bedding)

~~NF~~/370.7 /45° slickensides, striated parallel to core axis

CIF/ 371.8 - 372.9 / 90° (2-3) vertical fractures,

NF/374.0/45° slickensided, striated perpendicular to core axis

CIF/376.0/45°

376.9

SANDSTONE, bluish gray 5B 5/1, soft (wet?); 30-40% m sand, 60-70% f sand MEK

376.9 - 777.4 siltstone clasts to 2" oriented @ 0°

380.5 - 380.7 silty sandstone interbed

381.2 - 383.1 silty sandstone to siltstone interbed, M-LEC1ST

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Sampler Type & Depth	Recovery Ratio:	Blows/6 In	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log	Project: HEPA	Job No: 10-300-822	Borehole/Well No: W-829-15

NF / 391.4 - 383.4 / 70-90° closed healed w/ CaCO3

383.8 pyrite xtal 1/4"

386.0 - 389.0 30-40% med sand, 60-70% f sand MEK

HFZ / 386.0 - 389.0 / 1"-3"

NF / 385.5 - 387.3 / 70-90° healed, multiple, subparallel, anastamosing

NF / 385.8 - 387.3 / 45° multiple subparallel overprinting 70-90° fractures (see above)

387.3 - 389.5 50-60% med. sand, 40-50% f sand MEK

389.5 - 395.2 20-30% pebbles, subrounded, bluish gray, vesicular, to 1", pyrite mineralization in some vesicles

5-10% red vesicular subrounded pebbles to 3/4"

NF / 391.6 / 45° healed w/ CaCO3 1/8" thick

391.1 - 391.4 irregular siltstone (clast? interbed?) .75" in diameter

391.7 392.0 well cemented w/ CaCO3

395.2

irregular (erosional) contact @ ^

Sandy SILTSTONE, gray N 6/0, soft, (?): 15-25% vf sand MEK,

NF / 395.5 - 396.0 / 70-90° slickensided poorly developed, striations parallel to core axis

395.2 - 397.0 15% vf sand

397.0 - 399.0 25% vf sand

399.0 - 399.5

SILTSTONE, gray N 6/0, soft (moist), <15% sand, M-LEK, fine claystone laminations @ 0-10° grades into claystone interbed @ 401.0 - 401.4

NF / 401.1 - 401.4 / 90° partially healed CaCO3

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

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Project:	Job No:	Borehole/Well No:
HEPA	10-300-822	N-829-15

Headspace

Sampler Type & Depth	Recovery Ratio:	Blows/6 In	Circulation	Samp Qual	Sample ID	Lab/OVA/PID Results	Casing/Screen	Annulus Filler	Depth (ft)	Recovery	Graphic Log

401.4

Clayey SILTSTONE greenish gray 5GY 5/1, soft, (moist?); 60-70% silt, 20-30% clay 10-20% vf sand LEK

403.0-404.0?

SILTSTONE, greenish gray 5GY 5/1, soft, damp?); <15% sand, MEK

405.0-408.0 fine lamination of sandy siltstone MEK

C/F/ 408.0-409.0 90° open

411.5-412.8 silty sandstone interbed M-HEK, 30-40% silt, 60-70% vf-f sand

Total Depth = 414'

16:30 8/8/94

Additional Notes:

Soil Contamination:

0.0021 ppm TCE @ 36.2'

0.0013 ppm TCE @ 41.0'

0.00061 ppm TCE @ 50.0'

0.0066 ppm TCE @ 59.7'

0.00059 ppm PCE @ 144.5'

0.00082 ppm TCE @ 144.5'

Geiger/Müller pancake probe used to scan core, Eberline Model HP 210 serial number 4306731, calibrated 6/94 due for recalibration 6/95, BG = background level ~ 0.1 - 0.2 K CPM

HFZ = horizontal fracture zone inferred to follow bedding planes

BOREHOLE / WELL CONSTRUCTION LOG (cont.)

Project: HE PA

Job No: 10-0300-822

Borehole/Well No: W-829-15

Sampler Type & Depth | Recovery Ratio: | Blows/6 In | Circulation | Samp Qual | Sample ID | Lab/OVA/PID Results | Casing/Screen | Annulus Filler | Depth (ft) | Recovery | Graphic Log

Geophysical logs:

7/20/94 0'-138' 5" hole
ran video, caliper, gamma,
induction (resistivity & conductivity switched on EM log)
8/9/94 94'-412' gamma
80'-412' induction
80-412' caliper
0-248' video
8/29/94 0-250 video log of
blister
11/21/94 video log (pending)

Blister formed at 250' during grouting of annular space. Video log 8/29/94 shows tremie pipe (used to airlift) wedged in blistered section of casing. Blister drilled out on 11/17/94 by Sonne Fleming (driller), Joni Martin (geologist) and Chris Northart (driller's helper). Tremie pipe retrieved and additional well development done. Video log ran on 11/21/94 to view condition of casing.

WEISS ASSOCIATES

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BOREHOLE LOG NUMBER W-829-15

LOCATION Between B 829 ३ B-828

TO:

SAMPLE KEY:
◩ = 601 (bailed water sample)
☐ = TTLC
☒ = HE
■ = 8010

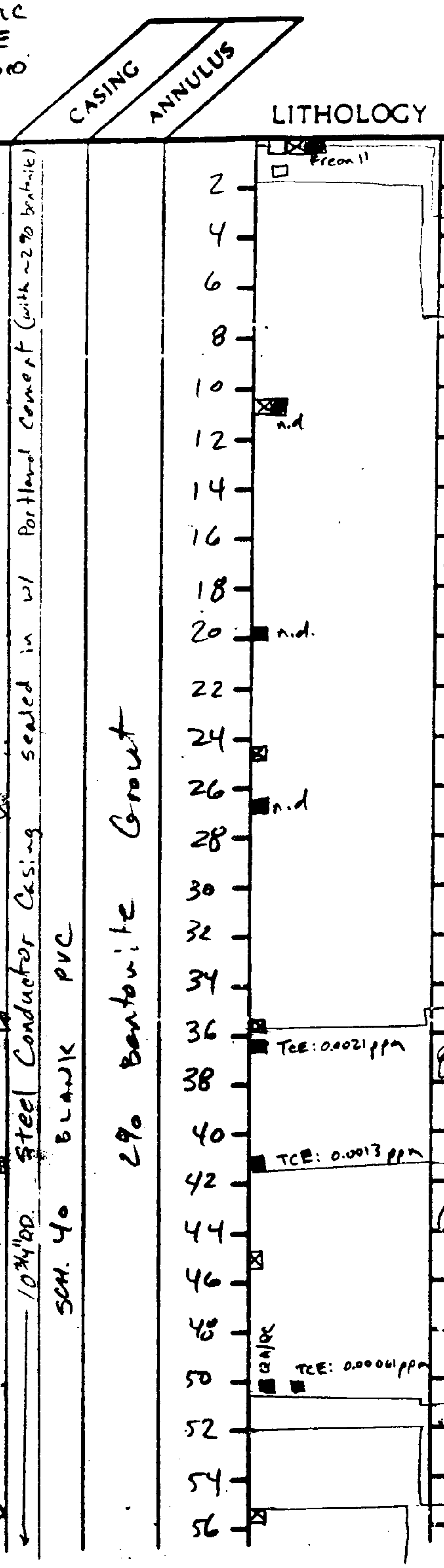
HYDROLOGY

0-55'
no water encountered
no water injected

26.3-26.7
core wet

cored down to 35', blew hole dry, no recharge overnite

* blew hole dry, no recharge after 6 hours, began injecting water



DESCRIPTION

Silty SAND (SM) HEK

0.5'

SANDSTONE HEK

1.8

Silty SANDSTONE w/ CLAYSTONE ३ SILTSTONE interbeds to 1.0',
PRIMARY K: MEK (s. siltstone)
LEK (interbeds)
Secondary K: MEK to HEK throughout

35.7

Brecciated CLAYSTONE
LE1K ; H-ME2K

41.5 - 45.0 (poor recovery (?))

Clayey SANDSTONE ME1K ; M-HE2K

50.7

SILTSTONE LE1K ; M-HE2K

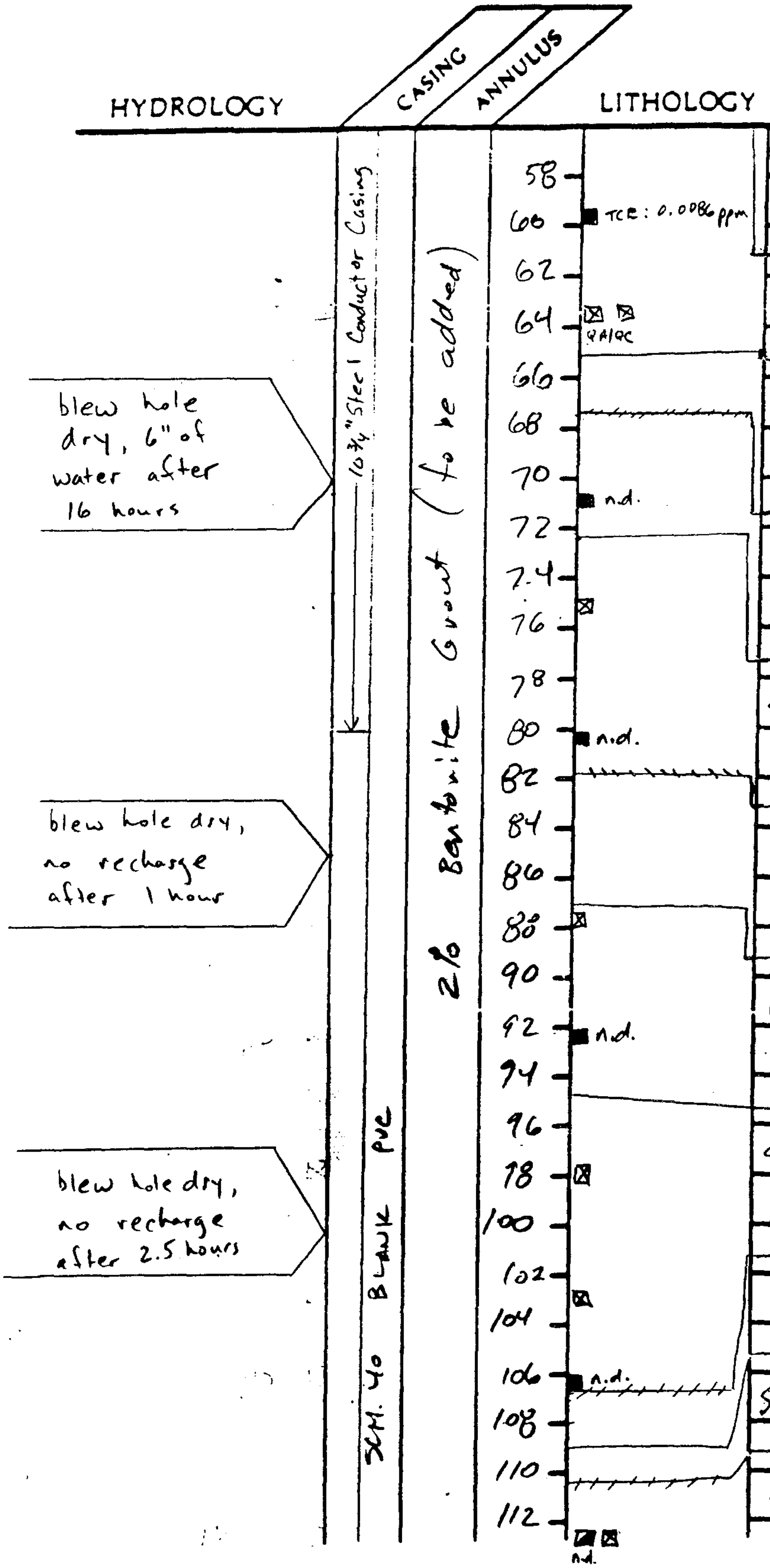
52.0

Brecciated CLAYSTONE LE1K ; M-HE2K (52.8
55.

BOREHOLE LOG NUMBER W-829-15

LOCATION Between 828 and 829

TO:



blew hole dry, 6" of water after 16 hours

blew hole dry, no recharge after 1 hour

blew hole dry, no recharge after 2.5 hours

DESCRIPTION

Brecciated CLAYSTONE, LE1K, M-HE2K

55.2

Sandy CLAYSTONE, LE1K, HE2K

64.5-65.0

Silty CLAYSTONE LE1K, M-HE2K

67.0-67.5

CLAYSTONE, LE1K, no 2K to M-HE2K

72.5

Silty CLAYSTONE, LE1K, ME2K to HE2K

81.3-82.8

Sandy CLAYSTONE, L-ME1K, M-HE2K

87.0

Clayey SANDSTONE, M-LE1K M=HE2K

94.5

Sandy SILTSTONE, L-ME1K, ME2K

106.5-106.9

SILTSTONE LE1K ; ME2K

108.8

SILTSTONE ; LE1K ; M-HE2K

110.5-110.7

Silty SANDSTONE, MEK1 SZ

BOREHOLE LOG NUMBER W-829-15

LOCATION Between 828 and 829

TO:

HYDROLOGY | CASING | ANNULUS | LITHOLOGY | DESCRIPTION

HYDROLOGY

blew hole dry, 5.5' of water after ~90 hours, took water sample

ran borehole video, cased off 0-80' with 10¾" casing

blew hole dry, no recharge after ~20 hours

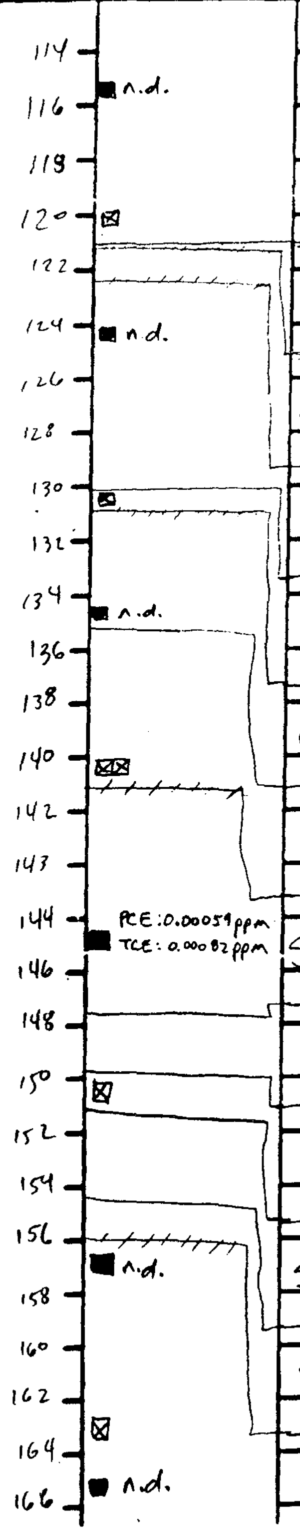
CASING

SCH. 40 BLANK PVC

ANNULUS

2% Bentonite Grout (to be added)

LITHOLOGY



DESCRIPTION

121.0

Brecciated SILTSTONE, LE1K, HE2K

121.6 - 121.8

CLAYSTONE MEZK

122.5 - 123.0

Silty, CLAYSTONE ME1K,

130.2

SANDSTONE M-HEK

130.9 - 131.2

CLAYSTONE LE1K, M-HE2K

134.9

SILTSTONE MEK-LEK 1st

141.6 - 142.6

Silty SANDSTONE, ME1K, M-HE2K

147.5

SILTSTONE, M-LE1K, ME2K

149.7

SANDSTONE, HE1K

151.0

SILTSTONE, ME1K

154.3

Sandy SILTSTONE, ME1K

155.6 - 155.9

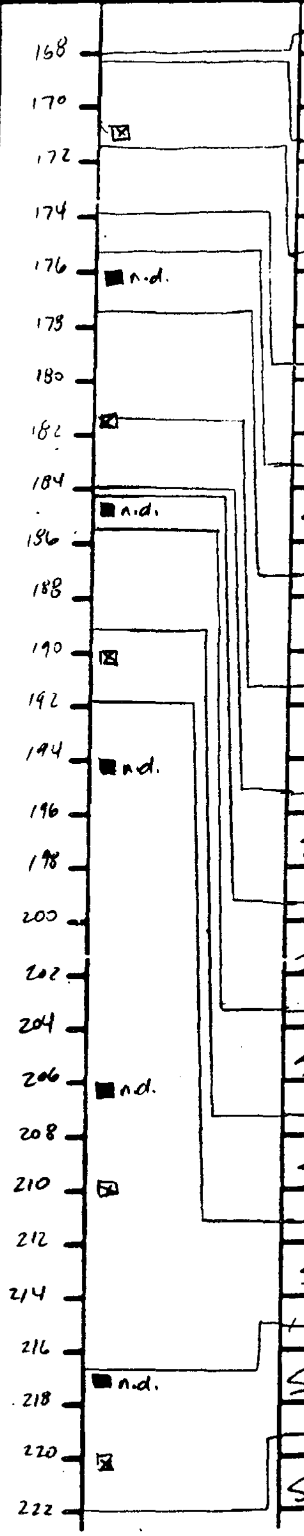
SANDSTONE HEK

BOREHOLE LOG NUMBER W-829-15

LOCATION Between B-829 & B-828

TO:

HYDROLOGY	CASING	ANNULUS	LITHOLOGY	DESCRIPTION
blew hole dry, no recharge after ~2 hours blew hole dry, 2" of water after 16 hours	SCH 40 BLANK PVC	2% Bentonite Grout		



168.0

Sandy SILTSTONE, MEK

168.5

SILTSTONE L-ME1K, ME2K

171.6 - 171.8

Silty SANDSTONE, ME1K, ME2K

173.7

SILTSTONE LE1K, M-HE2K

175.4

SANDSTONE, HE1K

177.6

SILTSTONE, ME1K, M-HE2K

181.5

SANDSTONE, ME1K, HE2K

183.5 - 184.0

SILTSTONE, LE1K, ME2K

184.4

SANDSTONE, HEK

185.5

SILTSTONE ME1K, M-HE2K

189.0

SANDSTONE HEK

191.7

SILTSTONE MEK, HE2K

216.4 - 217.0

Silty SANDSTONE ME1K, no 2K

222.0

Silty SANDSTONE to Sandy SILTSTONE ME1K, no 2K

BOREHOLE LOG NUMBER W-829-15

LOCATION Between B-829 & B-828

TO:

WEISS ASSOCIATES

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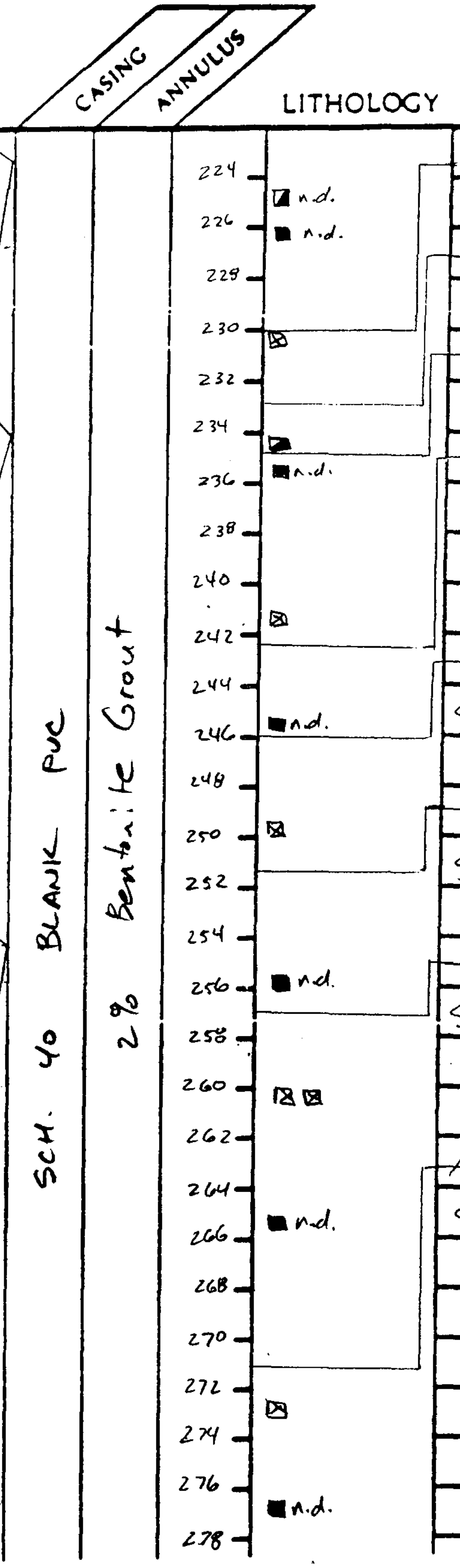
HYDROLOGY

blew hole dry, 3' of water after 5 hours, took water sample

blew hole dry, 1' of water after 1 hour, water @ 216.0' (bgs) after ~90 hours

blew hole dry, 2.2' of water after 4 hours, 20.5' of water after 21 hours,

blew out hole, 6.2' of water after 30 minutes, 6.3' of water after 75 minutes



DESCRIPTION

230.5

SILTSTONE, M-LE1K, no 2K

232.9

Sandy SILTSTONE, ME1K no 2K

235.0

Silty SANDSTONE, ME1K, ME2K

242.5

BreccIated CLAYSTONE (CMB)
LE1K, ME2K

246.0

Silty CLAYSTONE (CMB)
LE1K, ME2K

251.5

Sandy SILTSTONE to Silty SANDSTONE.
M-LE1K

257.0

Silty SANDSTONE M-HE1K

271.1 - 271.4

SANDSTONE, HE1K

BOREHOLE LOG NUMBER W-829-15

LOCATION Between B-828 and B-829

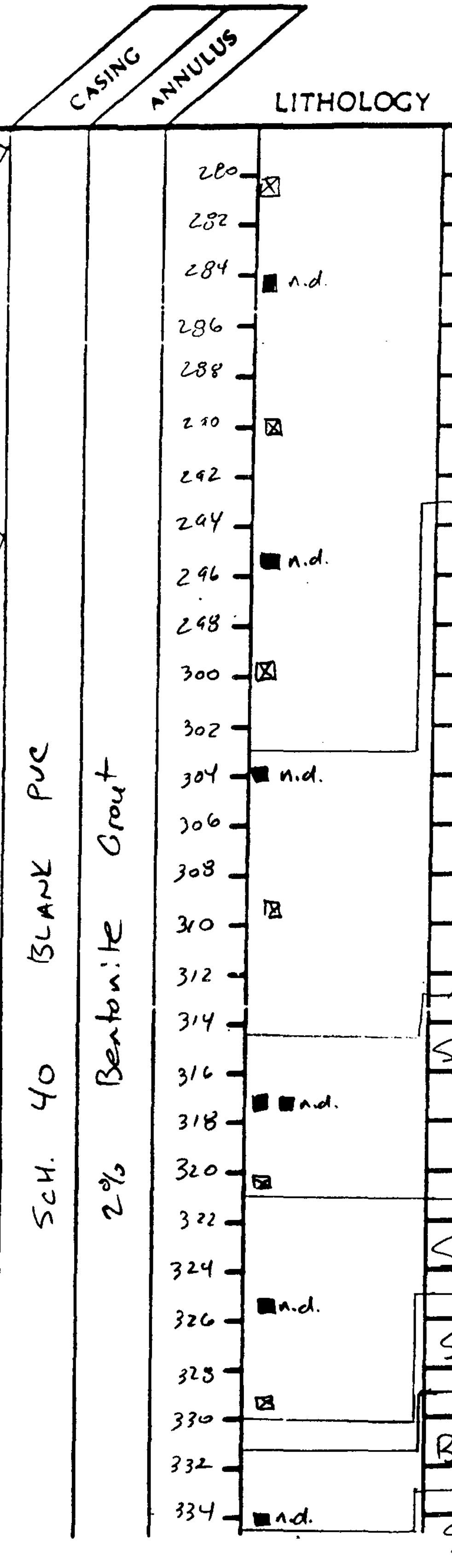
TO:

HYDROLOGY

1' of water in hole after 2 hours

blew hole dry, 1' of water in hole after 16 hours

blew hole dry, 36.7' of water after 2 hours



DESCRIPTION

SANDSTONE HE1K

303.0 (driller)

SILTSTONE LE1K, no 2K

314.2 - 314.4

Silty SANDSTONE, MEK 1st

320.8

SANDSTONE, HEK

330.0

Sandy SILTSTONE ME1K

331.4

Brecciated CLAYSTONE LE1K, HE2K

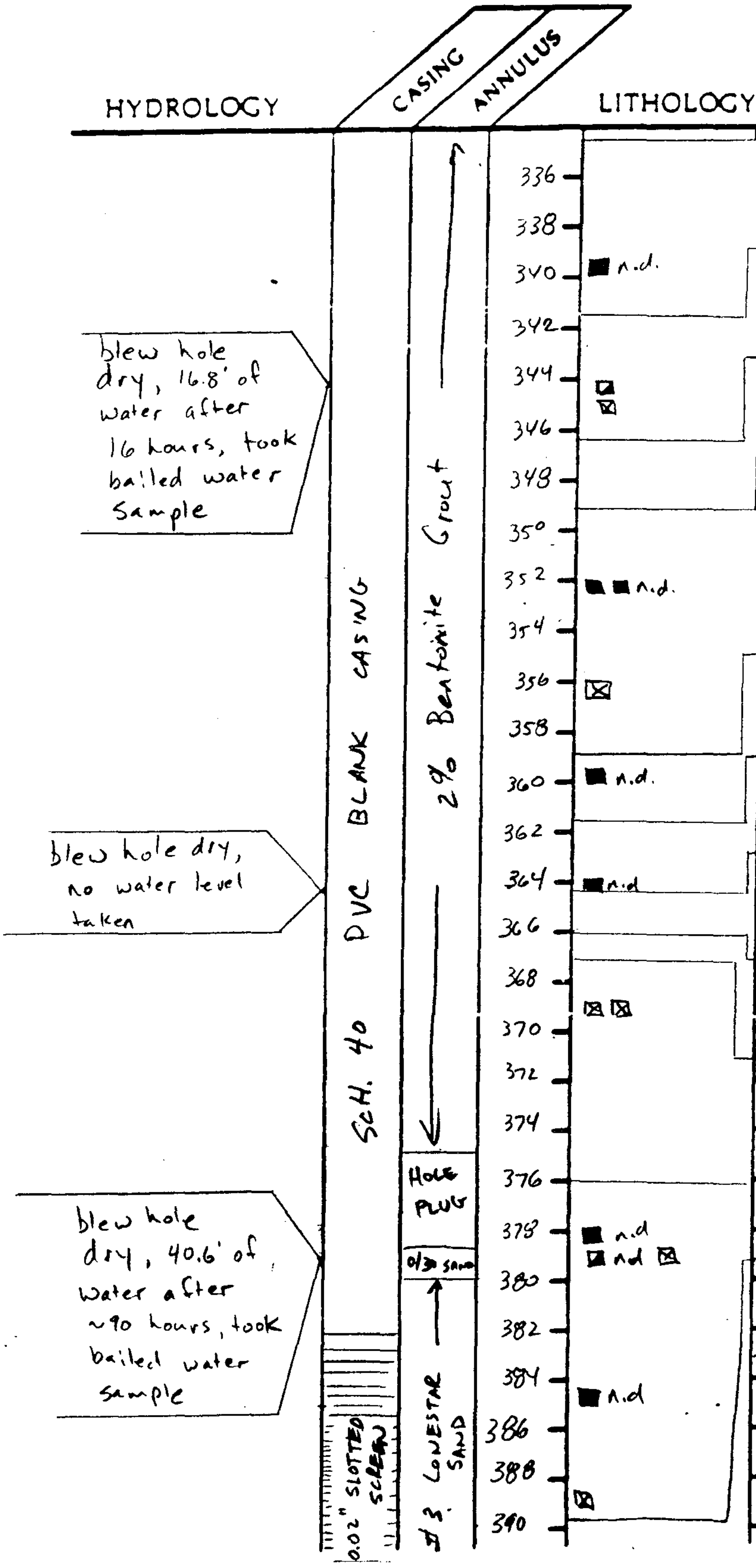
334.5

Sandy SILTSTONE ME1K

BOREHOLE LOG NUMBER W-829-15

LOCATION Between B-829 and B-828

TO:



DESCRIPTION

Sandy SILTSTONE ME1K

341.8

SANDSTONE HEK

346.5

SILTSTONE ME1K ME2K

349.2

Silty SANDSTONE M-HE1K, with ME1K interbeds

359.0

SANDSTONE HE1K

361.8

Silty SANDSTONE, MEK 1st

364.3

SANDSTONE HEK 1st

366.0

Silty SANDSTONE M-HE1K

367.3

SILTSTONE ME1K

376.9

SANDSTONE HE1K

389.5

Gravelly SANDSTONE, HEK

395.2

Sandy SILTSTONE

BOREHOLE LOG NUMBER W-329-15

LOCATION Between B-328 and B-829

TO:

HYDROLOGY	CASING	ANNULUS		LITHOLOGY	DESCRIPTION
	END CAP	#3 SAND	392		Gravelly SANDSTONE
		SLOUGH	394	■ n.d.	395.2
			396		Sandy SILTSTONE MEK
blew hole dry, 52.8' of water after 2 hours			398		399.0 - 399.5
			400	☒	SILTSTONE M-LE 1K M-E 2K
		Bentonite Seal	402		401.4
			404		Clayey SILTSTONE, LEK
			406	■ n.d.	403.0-404.0
			408		SILTSTONE, MEK
			410		
			412	☒	
blew hole dry, 52' of water after 30 minutes, recharging at a rate of 1' per 45 seconds, took bailed water sample			414	■ n.d	Total Depth = 414'

#3 sand	8 bags
#0/30 sand	1 bag
hole plug	4 bags
grout	bags

WEISS ASSOCIATES

WELL DEVELOPMENT DATA

By: DAMON Scott
Sheet 1 of 1
Well No. / Location: W-829-15
Job Name: HEPA
Date: 9/23/94 and 9/24/94
Job No: 10-300-822
Development Method(s): air lift
Depth to Water Before Development (ft): 336.5 (bgs)
Sounded Depth (ft):
Screened Interval (ft-ft): 382.2 - 392.2
Spec. Depth (ft):
Well Diameter (in): 4.5"

Time	Depth to Water (ft)	Gallons Pumped	Flow Rate (gpm)	Comments (water clarity, odor, methods, sounded depth, etc.)
3/4 9:30				air lift
10:00				stop air lift
10:10:15	371.5 (bgs)			
10:11:05	372.5 (bgs)			
10:53.00	345.0 (bgs)			Imhoff cone 3250 mL 5 ml silt, 10 ml clay
11:30				airlift
11.45				stop airlift
2:45	338.4 (bgs)			
		80 gallons		
24				
9:35	337.5 (bgs)			
9:50				start air lift
10:20				stop air lift
10:30				start airlift
10:40				stop airlift
10 50				start airlift
11:10				stop airlift
11 20				start airlift
11:30				stop airlift
1:30	336.4 (bgs)			Imhoft cone 5500 mL, 6 ml clay's silt
8/24/94		120 gallons		

Development Summary

Depth to Water During Pumping (ft):
Depth to Water After Development (ft): see above
Sounded Depth After Development (ft): see above
Total Pumping Time (min): see above
Total Amount Evacuated (gals): ~ 200 gallons

Approximate Yield: 0.5 - 1 gpm
Average Pumping Rate (gpm):
Pumping Rate Range (gpm):
Total H2O Injected (gals):

COMPOSITE LOG: MONITOR WELLS W-827-04 AND W-827-05

NOTES:

Wells W-827-04 and W-827-05 were drilled as a well pair.

During June 1990 W-827-04 was drilled to a depth of 320 feet. The hole was cored and geologically in detail. The hole was completed as a well, but no water has been found in the casing. Well W-827-05 was drilled during December 1990 and completed in January 1991 adjacent to well W-827-04 to find permanent water. It was cored and geologically logged in detail between 315 and 415.2(TD) feet. Both wells were geophysically logged at th time-of completion. In the late spring of 1991, an improved geophysical log including an induction log was run in well W-827-05. The induction log is presented here.

W-827-04
Geologic Logging: J. Pavletich, Weiss Associates, Emeryville, CA
Well Location: Approximately 260 feet south of Building 824, Site 300
Coordinates: N: 415,891.6; E: 1,703,895.2
Elevation, Shiner: 1,031.12 feet
Drilling: S. Fleming, P. C. Exploration, Inc., Roseville, CA
Dates Drilled: 6/28/90 to 7/19/90
Ground Water: First water encountered at approximately 297 feet 7/23/90, water at 301.4 feet; 10/10/90, well was dry
Geophysical Logging: Colog Inc., Petaluma, CA
Sampling Methods: 1.4-inch I.D. split-tube sampler, 1-2 feet Christensen Wireline Coring System, 5-55 and 58-320 feet

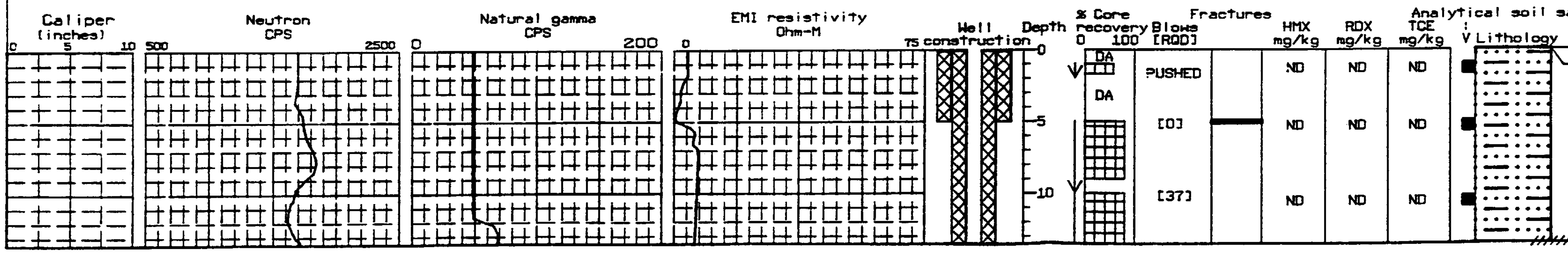
Drilling Method: 6-inch spadebit, air rotary, 0-5 feet
5-inch wireline coring, air-mist rotary, 5-55 and 58-320 feet
5-inch tricone bit, air-mist rotary, 55-58 feet
9-inch tricone bit, air-mist-foam rotary, ream, 0-323 feet
End cap broke during first attempt to install casing
9-inch tricone bit, air-mist-foam rotary, ream, 280-320 feet
4.5-inch I.D. PVC casing with 0.020-inch slots at 297.5-307.5 feet
Analytical Notes: Cis-1,2-DCE was identified in rock at the following concentrations: 130.1 feet: 0.0012 mg/kg; 150 feet: 0.0010 mg/kg; and 200 feet: 0.0007 mg/kg. No other VOCs were identified in soil or rock samples above a detection limit of 0.0002 mg/kg.

W-827-05
Geologic Logging: J. Pavletich, Weiss Associates, Emeryville, CA
Well Location: Approximately 260 feet south of Building 824, 8 feet north of W-827-04, Site 300
Coordinates: N: 415,896.6; E: 1,703,898.8
Elevation, Shiner: 1,031.38 feet
Drilling: S. Fleming, P. C. Exploration, Inc., Roseville, CA
Dates Drilled: 12/6/90 to 1/3/91
Ground Water: First water encountered at 410 feet, 12/21/90
Sampling Methods: Christensen Wireline Coring System, 10-45 and 82-415.2 feet. Cores were not logged in detail above 320 feet.
Geophysical Logging: Colog, Inc., Petaluma, CA
Recoveries and RQDs over 100% reassigned to the corresponding core run.
Recovery histogram shows percent recovery and inferred recovery location.
DA means drill ahead; NR means no recovery.

Drilling Method: 9-inch tricone bit, air rotary, 0-9 feet
5-inch wireline coring, air-mist rotary, 10-45 and 82-400 feet
5-inch wireline coring, air-mist-foam rotary, 400-415 feet
6-inch tricone bit, air-mist rotary, 0-82 feet
9-inch tricone bit, air-mist rotary, ream, 0-413 feet
10.25-inch steel casing at 0-5 feet
4.5-inch I.D. PVC casing with 0.020-inch slots at 379.2-408.4 feet
Analytical Notes: No other VOCs were identified in soil or rock samples above a detection limit of 0.0002 mg/kg. VOC constituents were identified at the analytical detection limit of 0.0002 mg/kg of Freon 113 at 322.5 feet and Freon 11 at 366.7 feet. Detection limit of HMX and RDX is 0.001 mg/kg. ND indicates none detected
Estimates of gravels, sands, and fines are field visual estimates.
Notation of Bedding and Fractures: [Depth(s)/dip(s)°/comment(s)]

INDEX TO SYMBOLS

- BLADDER PUMP
- SUBMERSIBLE PUMP
- WATER ENCOUNTERED
- STATIC WATER LEVEL
- ↓ DRIVE SAMPLE OR CORE RUN
- ■ ANALYTICAL SOIL SAMPLE
- ???? APPROXIMATE CONTACT
- ////// GRADATIONAL CONTACT
- ▩ #0 SAND
- ⛆ SAND PACK
- ■ BENTONITE
- ☰ SLOTTED CASING
- ▨ NEAT CEMENT GROUT
- ▩ CEMENT-BENTONITE GROUT
- ▩ CEMENT-CAL SEAL GROUT
- ▩ SLOUGH MATERIAL
- ■ CLOSED FRACTURES
- ◪ OPEN FRACTURES
- ▩ FRACTURE ZONE



SITE 300

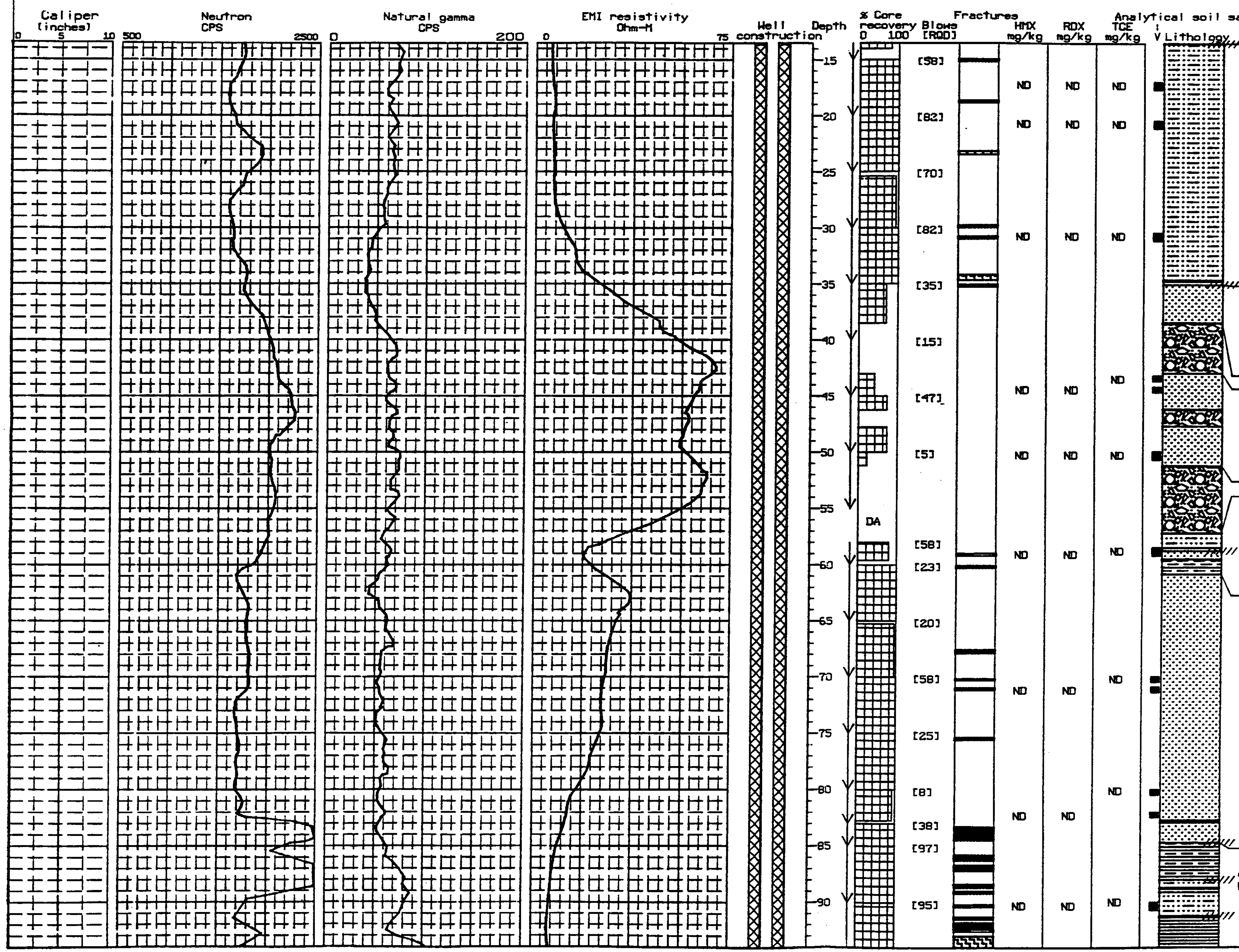
Lithologic descriptions and/or remarks

(0-415.2) TERTIARY SEDIMENTARY ROCKS

(0-13.5) SILTY SAND, [SM], brown, moist, loose to medium dense, very fine to fine grained, 20-30% silt, 15-20% clay, common specks of caliche, low to moderate estimated permeability
[5/90°/fracture coated with caliche]
tan, dry, medium dense, 5-10% medium sand, and rare round pebbles to 0.5 inch below 4.7 feet; abundant caliche stains, stringers, veins, and cementing at 5 feet, sandstone cobble at 5-5.2 feet; red Fe-oxide stains and patches at 7 feet; caliche stained patches and nodules to 0.5 inch at 7-7.7 feet; light brown, rare weathered mica flakes, and moderate estimated permeability below 8 feet; scattered Fe-oxide concretions to 0.1 inch at 10-11 feet; Fe-oxide replacing organic fragments at 12-14 feet

COMPOSITE LOG: MONITOR WELLS W-827-04 AND W-827-05 (CONTINUED)

SITE 300



Lithologic descriptions and/or remarks

(13.5-35.1) SILTY SANDSTONE, brown, dry, moderately indurated, very fine grained, 15-20% silt, 10-15% clay, minor Fe-oxide stained patches and stringers, common weathered mica flakes, low estimated permeability

5-10% clay at 15.5 feet; common Fe-oxide stained patches and stringers replacing organic fragments at 17-18 feet; very fine to fine grained, 20-25% silt, 5-10% medium sand, common organic fragments and moderate estimated permeability below 18 feet; sandstone interbed at 18.9-19 feet: tan, very fine grained, 20-30% silt, 10-20% clay, some mica, and low to moderate estimated permeability below 20 feet

[15.1/0°/fracture with slickensides; 18.8/5°/fracture with Fe- and Mn-oxide; fracture zone healed with Mn- and Fe-oxide and carbonate at 23.2-23.5 feet]

very fine to fine grained, 5-10% clay, common Fe-oxide stains and moderate estimated permeability below 24 feet; 15-25% silt below 27 feet

[fractures healed with Fe- and Mn-oxide and/or silica and carbonate: 29.9/0°-5°/several, 30.9/90°, and 34.2/90°; fracture zone with caliche and Fe-oxide at 34.2-34.7 feet]

brown, moderately to well indurated, 20-30% silt, and moderate estimated permeability below 31 feet

brown claystone rip-up clasts to 0.5 inch at 34.7 feet; brown claystone interbed at 34.7-35.1 feet

(35.1-38.5) SANDSTONE, dark gray, dry, moderately indurated, fine grained, 10-15% very fine sand, 5-10% silt, 5% clay, moderate to high estimated permeability

claystone rip-up clasts to 0.5 inch at 35.1-35.6 feet; heavy Fe-oxide staining and low estimated permeability at 35.7-36 feet; fine to medium grained, 10-15% silt and very fine sand, and <5% clay below 37.5 feet; 5-10% round pebbles to 0.5 inch at 38.2-38.5 feet

[35.2/90° and 90°/intersecting fractures]

(38.5-43) CONGLOMERATE, no recovery; from driller

(43-51.2) SANDSTONE, dark blue-gray, dry, moderately indurated, medium to coarse grained, 5-10% very fine to fine sand, <10% fines, <5% pebbles to 0.1 inch, high estimated permeability

5-10% pebbles at 43.2-43.5 and 44.2-44.7 feet; cuttings and driller indicate conglomerate interbed with volcanic pebbles to 1 inch at 46.2-47.7 feet; 10-15% very fine to fine sand below 47.7 feet; 10-20% pebbles near 47.7 and 51.2 feet; possible worm burrows filled with silica at 47.9, 48.1, 48.2, and 49.5 feet

(51.2-57.2) CONGLOMERATE, no recovery; from driller,

(57.2-60.8) interbedded CLAYSTONE, SILTSTONE, and SANDSTONE, low estimated permeability

brown silty sandstone with a moderate estimated permeability at 57.2-58.5 feet; sandstone with moderate estimated permeability at 58.7-59.5 feet; brown silty claystone at 58.5-58.7 feet; light gray clayey siltstone at 59.5-60.8 feet

[59/45° and 65°/intersecting open fractures, 60.2/90°/fracture healed with Fe- and Mn-oxide and carbonate]

(60.8-84.7) SANDSTONE, dark gray, dries blue-gray, dry, moderately indurated, fine grained, 10-20% very fine sand, 5-10% silt, <5% clay, common Fe-oxide stained patches, rare weathered mica flakes, rare rounded pebbles to 0.2 inch, moderate estimated permeability

brown at 60.2-61.8 feet; clayey siltstone lense at 64.1 feet; several tan claystone clasts at 70.2-70.4 feet; very fine grained, 10-15% silt, and <10% clay at 67.7-68, 68.4-68.7, 71.1-71.3, 72.2-72.8, and 74-74.4 feet; very fine to fine grained, 10-20% medium sand, <15% fines, and tan claystone clasts to 0.5 inch at 76.3-77 feet; cross-bedding at 77.5-78, 78.2-79, and 80-82 feet; common carbonate blebs to 0.1 inch at 78.2-79 feet; common tan claystone clasts to 1 inch at 80.2-81.5 feet

[fractures: 67.7/38°/Fe-oxide stained; 70.3/0°-10°/several intersecting and healed (with silica ?); 71.1/50°, and 75.3/90°/ healed with silica]

gray-brown silty claystone interbed at 82.7-82.9 feet

gray-brown, very fine grained, 10-15% silt, 1-5% fine sand and minor cross-bedding below 82.9 feet

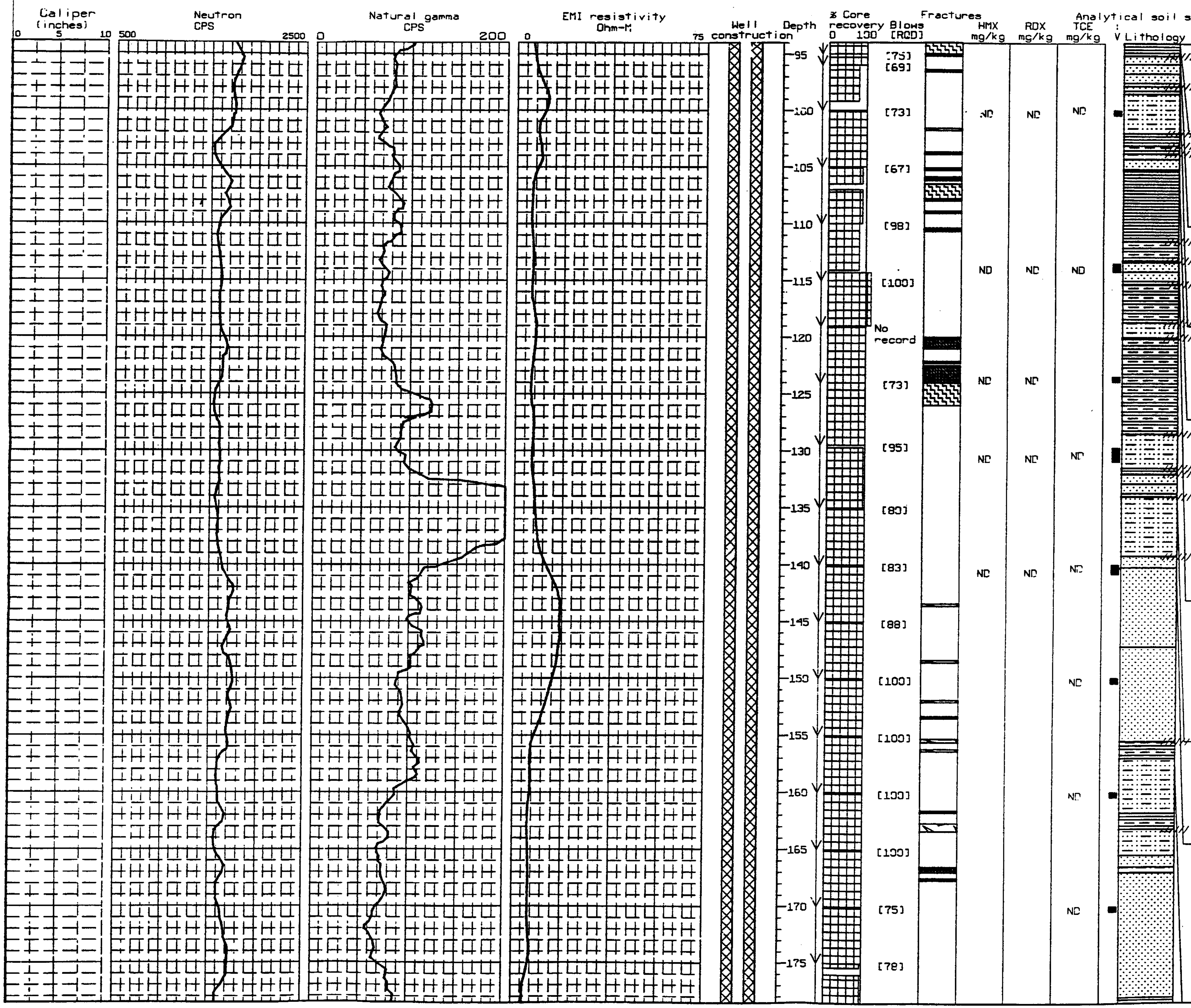
[fractures: 83.3/80°/Mn-oxide, 83.4/22°/Mn- and Fe-oxide, and 83.5-84.5/45° and 90°/intersecting and healed with carbonate and Mn-oxide; fracture zone at 84.5 feet; 83.5-84.5/90°/fracture contact between sandstone and claystone]

(84.7-88) SILTY CLAYSTONE, gray-brown, dry, moderately indurated, 20-25% silt, 5-10% very fine to fine sand, common laminations and cross-bedding, low estimated permeability

Fe-oxide stained lenses and patches at 84.7-85.4 feet; organic fragments being replaced by Fe-oxide at 87.8 feet

[fractures sealed with Fe- and/or Mn-oxide: 85.9/0-5°, 86.2/10°, 86.7/24°, 86.8/30°, 87.1/0-10°/several, 87.1/80°, 88.7/50°, 89/30°, and 89.1/30°; 88.4/45°/fracture sealed with carbonate]

COMPOSITE LOG: MONITOR WELLS W-827-04 AND W-827-05 (CONTINUED)



SITE 300

Lithologic descriptions and/or remarks

(88-91.2) SILTY SANDSTONE, orange-brown, dry, moderately indurated, very fine grained, 20-30% silt, moderate estimated permeability

silty claystone interbed at 88.7-89.1 feet; cross-bedded with white sandstone laminations at 89.3-90 feet; silty claystone clasts to 0.1 inch at 89.6; distorted silty claystone stringers at 90.2-90.3 feet
[90.3/70°-80°/partially healed fracture with Fe-oxide]

(91.2-95.1) CLAYSTONE, brown, dry, poor to moderately indurated, <10% silt and very fine to fine sand, scattered mircofractures throughout, low estimated primary permeability

pale gray and low estimated fracture permeability at 91.2-92.8 feet
[fractures with Fe-oxide: 91.4/90°-0°/healed, 91.4/0°, 91.8-92.4/60°, 28°, and 90°/intersecting, and 92.4/25°/open; possible fracture zone with moderate estimated fracture permeability at 93-95 feet]

(95.1-98.5) CLAYEY SANDSTONE, orange-brown, dry, moderately indurated, fine grained, 15-20% very fine sand, 20-25% clay, 15-20% silt, Fe-oxide stained patches, carbonate patches, moderate estimated permeability

scattered organic fragments and small Fe-oxide 0.1 inch concretions at 96-97.7 feet; 10-20% clay, 10-15% medium to coarse sand, 10-15% very fine sand, and 5-10% silt at 97.7-98.5 feet
[fractures: 95/0°/Mn-oxide stained, 95.1/28°/slickenslides, and 96.5/0°/Fe-oxide]

(98.5-102) SILTY SANDSTONE, orange-brown, dry, moderately indurated, very fine grained, 20-30% silt, 10-15% clay, abundant Fe-oxide patches and lenses, low to moderate estimated permeability

clayey sandstone interbed at 98.7-99 feet; orange-brown, medium grained sandstone interbeds with 10-20% fine sand and <15% fines at 98.5-98.7 and 99-99.7 feet; some gray silty claystone laminations at 101.4-101.8 feet
[101.7/80°/fracture partially healed with Fe- and Mn-oxide]

(102-111.5) CLAYSTONE, gray, dry, moderately indurated, 5-10% silt and very fine sand, rare weathered mica, (heavy Fe-oxide stained upper contact), low estimated permeability

heavy Fe-oxide stain on silty claystone contacts at 103-103.2 feet; brown silty claystone interbed at 103.1-103.8 feet; gray silty sandstone interbed at 103.8-104.3 feet; orange-brown sandstone interbed with moderate estimated permeability at 104.3-105.2 feet; microfractured at 106.5-107.8 feet; orange-brown below 108 feet; minor carbonate re-cementing at 109.8-110.5 feet; heavy Fe- and Mn-oxide staining at 110.2-110.5 feet; blue-gray below 110.7 feet
[fractures coated with Fe- and/or Mn-oxide: 103.7/82°, 105.2/90°, 106/45°, 106.2/45°, 107.2/10°, 107.9/30°-0°, 108.1/20°, and 109/0°; gouged fracture zone with heavy Fe- and Mn-oxide staining at 106.5-107.8 feet; 110.5/0°/fracture healed with carbonate; 110.7/0° and 30°/interecting fractures with Fe- and Mn-oxide]

(111.5-128.5) SILTY CLAYSTONE, blue-gray, dry, moderately indurated, 10-30% silt, 10-20% very fine to fine sand, low estimated permeability

irregular white carbonate mottling at 110.5-112.2 feet; clayey sandstone interbed at 113.2-115.3 feet; irregular pods and lenses of clayey sandstone and silty claystone at 114.2-115.2 feet; abundant mica at 115.3-128.5 feet; white carbonate blebs to 0.1 inch at 117-117.2 feet; silty sandstone interbed at 118.7-120 feet; dark gray below 120 feet; mottled black with organic matter at 121.2-124 feet
[healed fractures: 120-121/80°-90°/healed with carbonate and pyrite, 122.2/65°/slickensides, and 122.5-124/80°-90°/healed with white (silica?); healed microfracture zone at 124-126 feet]

(128.5-139.2) SILTY SANDSTONE, blue-gray, dry, moderately indurated, very fine grained, 20-30% silt, 10-20% clay, abundant mica, some white blebs, moderate estimated permeability

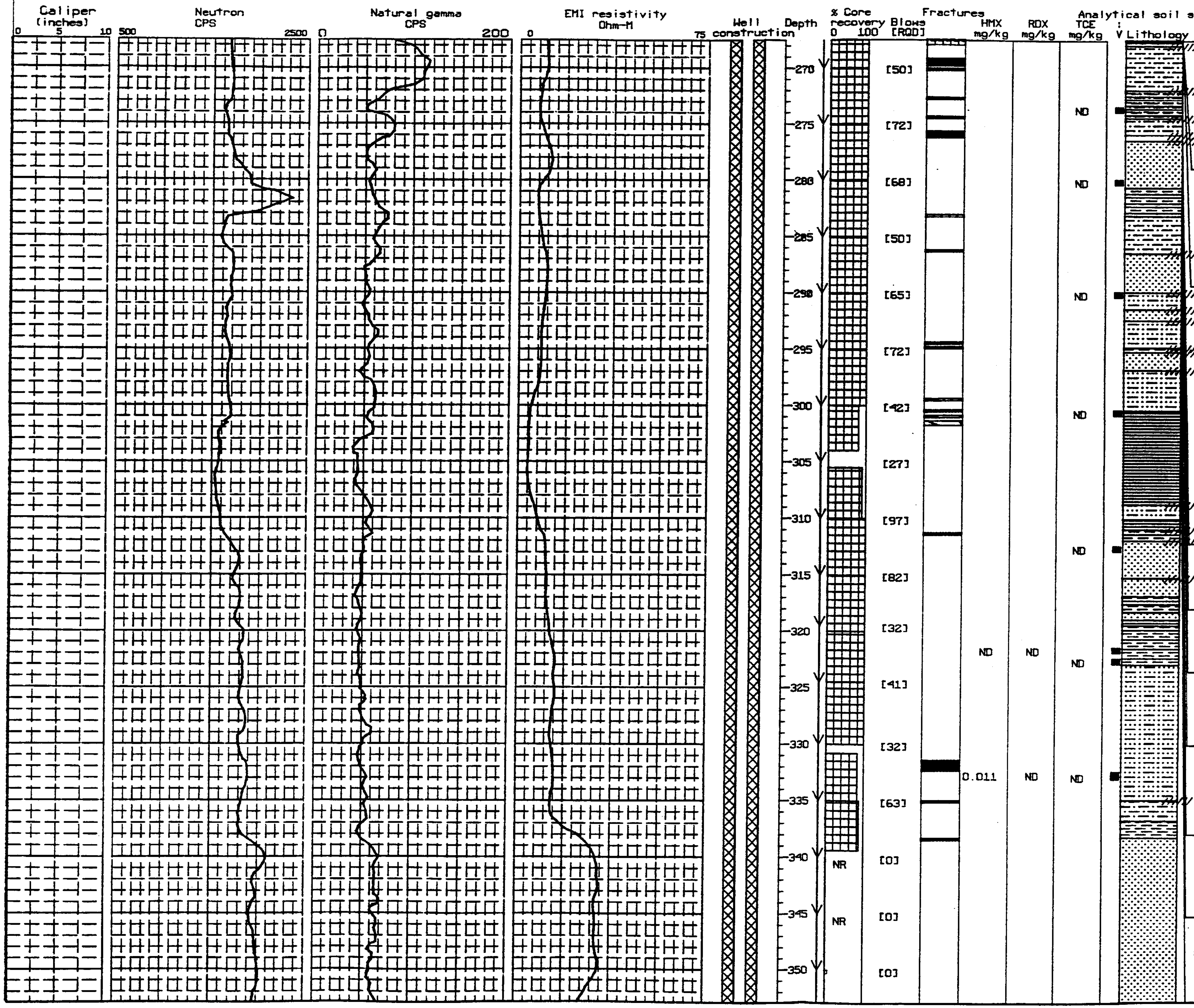
blue-gray silty sandstone interbed with a moderate estimated permeability at 128.5-131.5 feet; silty claystone interbed at 131.5-132 feet; clayey sandstone interbed with abundant white blebs at 132-134 feet; 10-20% medium to coarse sand and scattered pyrite blebs below 135 feet; rare round pebbles to 0.2 inch at 137.7 feet; orange-brown below 139 feet

(139.2-155.5) SANDSTONE, orange-brown, dry, moderately indurated, very fine to fine grained, 10-15% medium sand, 10-15% silt, 5-10% clay, moderate to high estimated permeability

15-20% medium sand, <5% clay, and some Mn-oxide staining at 139.2-140.2 feet; rare pebbles to 0.2 inch at 140.7 feet; fine to medium grained at 142.5-145 feet; scattered worm burrows filled with white (silica ?) at 143.5-145, 145.7, 146.6, 146.9, and 149.8 feet; medium grained, 10-15% very fine to fine sand, <5% clay, and some green grains at 147.2-155.5 feet; very fine to fine grained lense at 149.5-149.7 feet; thinly interlaminated light and dark sandstone at 148.5-149.5 feet; yellow-brown below 153 feet
[fractures: 143.5/65°, 148.5/38°/open, 152/36°/open, 153.4/subhorizontal/Fe-oxide stains, 156.2/63°/open, and 155.3-155.6/84°/open; 150-155/16°/some black silty sandstone laminations]

COMPOSITE LOG: MONITOR WELLS W-827-04 AND W-827-05 (CONTINUED)

SITE 300



Lithologic descriptions and/or remarks

(245.3-254) SANDY SILTSTONE, brown, dries light.brown, damp, moderately indurated, 15-35% very fine to fine sand, 10-15% clay, low estimated permeability

silty sandstone interbeds at 246.3-246.7, 247.8-248.4, 250.4-251.8, and 252.8-254 feet; 20-35% very fine sand, 15-20% clay at 250.4 feet; feet; 15-20% silt at 252.8-254 feet

[subhorizontal, open fractures at 245.4, 245.6, 246.3, 246.6, 247.7, and 248.5 feet; fractures with Mn-and/or Fe-oxide: 245.7/25°, 246.8/23°, 247.3 and 247.5/16°/bornite-like stains, 250.4/0°, 251.4/0°, and 252/0°, 252.4/36°, and 252.7/8°;rubbly fracture zones at 248.5-250 and 252.8-254 feet; 247-248/0°/bedding]

(254-260) SILTSTONE, brown, dries to light brown, damp, moderately indurated, 10-15% clay, 10-15% very fine sand, low estimated primary permeability, moderate estimated fracture permeability

Fe- and Mn-oxide stains, rubbly, possible claystone interbeds and some slickensides showing dextral movement at 255-257.5 feet; light brown, poorly to moderately indurate clayey siltstone interbed with a high estimated fracture permeability at 257.5-260 feet

[fractures with Mn- and/or Fe-oxide: 254/29°, 254.3/0°, 254.3-254.6/90°, 254.7/37°, and 255/0°; intense fracture zone at 255-260 feet]

(260-276) SANDY SILTSTONE, brown to light brown, damp to dry, moderately indurated, 15-25% very fine sand, 5-10% clay, low estimated permeability

silty sandstone interbeds at 261.3-261.5 and 262.3-262.6 feet; sandy claystone interbed at 262.6-263.3 feet; gray, moderately to well indurated silty claystone interbed with a moderate estimated fractured permeability at 265.5-268 feet; brown, dries blue-gray, well indurated sandy siltstone with 15-20% very fine sand, 10-15% clay, and a moderate estimated fractured permeability below 268 feet; blue and black cross-laminations at 270.5 feet; cross-bedding at 271-272.5 feet; gray-brown, dry silty claystone interbed at 272-274.5 feet

[fractures with Fe- and/or Mn-oxide: 260, 260.3, 260.5, and 260.8/subhorizontal, 261.2/32°, 261.8/45°, and 261.6-262.3/90° and 64°; 263.4-263.7/0°/wood and leaf fossils, 263.8-264.4/77°, 266.5/0°, 266.7/27°, 266.8/32°, 267/0°, and 268/42°; fracture zone with green stains at 267-268; fracture zone at 273.5-275 feet; fractures with green stains: 265.8/43°, 266.3/0°, 268/31°, 269.3/0°, 269.6/21°, 269.8 and 270/18°; fractures healed with carbonate: 270.1/90° and 0°/intersecting , 270.2/0°, 272.2/0° and 90°/intersecting, 272.7/0° and 40°/intersecting, and 274.5/0°, and 275.7-276.3/60°; 273/70°/fracture with slickensides; 268/subhorizontal/bedding]

(276-280.7) SANDSTONE, gray, dry, moderately indurated, very fine to fine grained, 5-10% silt, <5% clay, coarsens downward to fine to medium grained, moderate porosity, moderate estimated permeability

dark gray silty sandstone interbed at 276-276.5 feet; fine to medium grained, and 10-20% very fine sand below 278 feet

(280.7-283.2) SILTY CLAYSTONE, dark green-black, dry, moderately to well indurated, 20-30% silt, 10-15% very fine to medium sand, abundant quartz blebs to 0.1 inch, scattered organic fragments, very low estimated permeability

minor pyrite at 280.5 feet

[healed, subhorizontal fracture zone at 283.2 feet]

(283.2-286.5) SANDY SILTSTONE, blue-gray, dry, well indurated, 10-20% very fine to fine sand, 5-10% clay, 5-10% medium sand and mica, low to moderate porosity, low to moderate estimated permeability

black (Mn-oxide ?) stained bedding planes with load structures at 285.4, 285.5 and 285.6 feet

[286.2/30°/fractures healed with carbonate]

(286.5-292.5) SANDSTONE, blue-gray, dry, moderately indurated, very fine to fine grained, 5-10% medium sand, 10-15% silt, 5-10% clay, abundant hornblende, pyroxene, and mica grains, moderate porosity, moderate estimated permeability

fine to medium grained at 287-287.3, 287.6-287.9, and 288-239.6 feet; rare pebbles to 0.1 inch at 289.9 feet; blue-gray silty sandstone interbed at 290-291.5 feet; (silica ?) filled worm burrows at 290-290.5, 291-291.5, and 292-292.4 feet

(292.5-296.9) SILTY SANDSTONE, blue-gray, dry, moderately indurated, very fine grained, 15-20% silt, <5% clay, abundant mica, moderate porosity, low to moderate estimated permeability

blue-gray siltstone interbed at 294.9-295.3 feet; blue-gray sandstone interbed with 20-30% fine sand and 5-10% silt at 295.3-296.9 feet

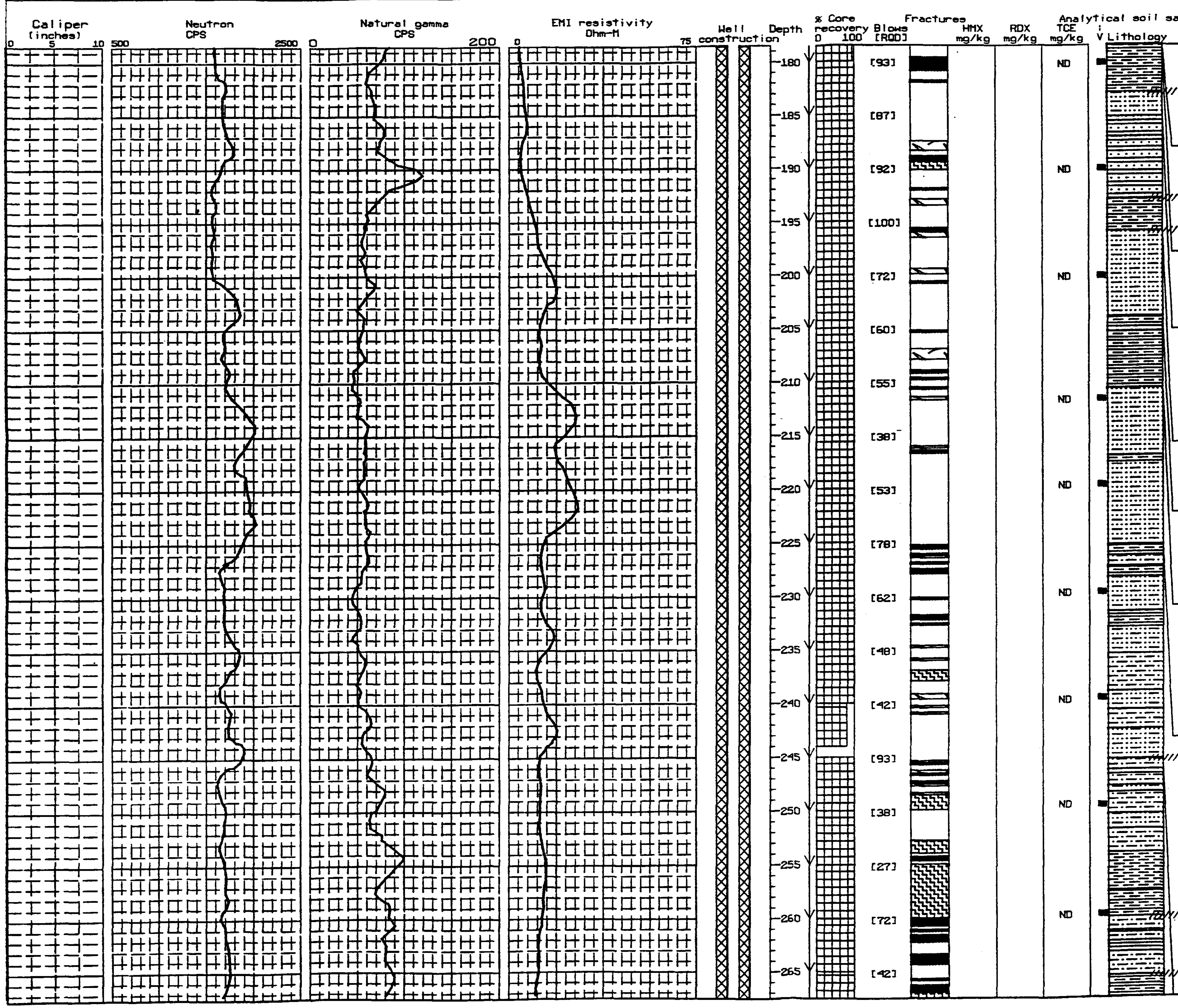
[fractures healed with carbonate: 294.5/10°-0° and 294.9/0°-5°/several and intersecting]

(296.9-300.5) SILTY SANDSTONE, blue-gray, dry, moderately indurated, fine to medium grained, 20-30% very fine sand, 15-20% silt, 5-10% clay, moderate porosity, moderate estimated permeability

very poorly indurated at 298-298.8 feet; light gray, very fine grained, 20-30% silt, and abundant mica below 299.5 feet

[fractures: 299.5/40°/open with slickensides and 300.5/35°]

COMPOSITE LOG: MONITOR WELLS W-827-04 AND W-827-05 (CONTINUED)



SITE 300

Lithologic descriptions and/or remarks

(155.5-165.5) SILTY SANDSTONE, gray to green-gray, damp, moderately to well indurated, very fine to fine grained, 25-35% silt, <5% clay, some pyrite and mica, tight, poorly sorted, low to moderate porosity, low estimated permeability

green to gray-green silty claystone interbed at 155.5-157 feet; sandstone lense at 156 feet; gray silty claystone interbed at 161.8-163.2 feet; green-gray and rare claystone fragments below 163.2 feet

[fractures: 156.2/63°/open, 161.7/18°/with slickensides, and 162.7-163.2/subvertical/open with white carbonate veinlets and slickensides at 90°; 165.5/28°/unit contact]

(165.5-178) SANDSTONE, to locally silty sandstone, dries blue-gray, damp, well indurated, medium to coarse grained, 5-15% silt, poorly sorted, moderate to high porosity, moderate estimated permeability

very coarse grained with medium to coarse grained biotite flakes and pyrite below 170 feet; sandy siltstone interbed with pyrite nodules to 1 inch at 166.5-167 feet; no production at drilling depth at 175 feet; 15-20% coarse pebbles at 176-176.3 feet

[fractures: 167.5/15°/carbonate and 166.5-167/90°/moist (to wet?) and healed with pyrite; 174-176.2/28°/bedding]

(178-185.3) CLAYEY SILTSTONE, gray-green, dry to damp, moderately indurated, 25-40% clay, 5% very fine sand, low estimated permeability

10-15% very fine sand at 182-183 feet; gray silty sandstone interbed with abundant sulfides and biotite and low estimated permeability at 183-185.3 feet

[fractures: 179.7-181/90°/with vertical slickensides and 182/59°/with slickensides at 19°]

(185.3-196) SANDY CLAYSTONE, gray-green, damp, moderately indurated, 20-35% silt, 15-20% very fine to fine sand, some pyrite and mica, low estimated permeability

porous, green silty sandstone interbed at 187.2-187.6 feet; moderately to poorly indurated, 15-30% very fine sand, 15% silt, and moderate estimated fracture permeability at 187.6-193 feet; green-gray clayey siltstone interbed at 193-196 feet

[fractures: 187.6-188.5/90°/open, 189-189.5/90°/Mn-oxide stains, 193-193.6/74°/open, and 195.7/40°/carbonate; crumbly green gouged fracture zone at 189.5-190.3 feet; 192.1/15°/0.3-inch thick carbonate vein]

(196-204) SILTY SANDSTONE, gray, dries blue-gray, damp (to dry ?), well cemented, very fine to fine grained, 20-35% silt, 10-15% clay, low to moderate porosity, low estimated permeability

claystone rip up clasts at 195.5-196.5 feet; brown below 200 feet

[fractures: 196.1/0°/carbonate stains, 196.6/73°/open, 196.8/41°/open, 199.5-200/90°/open, and 200.8/28°/Mn-oxide]

(204-210.7) SILTY CLAYSTONE, light brown, dry to damp, well indurated, 15-25% silt, <5% very fine sand, bedding dips 5°, thinly laminated, low estimated permeability

sandy siltstone interbed at 205-205.4 feet; high estimated fractured permeability at 206.7-208 feet; 15-20% very fine to fine sand at 207-209 feet

[fractures: 205.4/28°/Mn-oxide, 207-208/0°/open with local Mn-oxide stains, 209-209.2/0°/Mn-oxide and green stains, 209.8/34°/brown stains, and 210.7/10°/Mn- and Fe-oxide blebs; undulose contacts at 204 and 210.7 feet]

(210.7-225.3) SILTY SANDSTONE, brown, dries blue-gray, damp, moderately indurated, very fine to fine grained, 10-15% silt, poorly sorted, massive, moderate porosity, low to moderate estimated permeability

yellow-brown clayey siltstone interbed at 217-217.6 feet; some medium sand at 217-220 feet; no production at drilling depths 220 and 225 feet, 20-25% silt at 220.2-221.5 and 224.3-224.7 feet; dry, poorly indurated, and very fine to medium grained with local coarse sand at 221.5-224.3 feet; 10-15% silt below 224.7 feet; abundant pyrite and volcanic fragments at 223 feet

[fractures: 211.5/40°/open, 211.7/18°/open, 216.2/49°/open, 216.5/38°/Mn-oxide, and 216.7/0°/Mn-oxide, undulating lower contact at 225.3 feet]

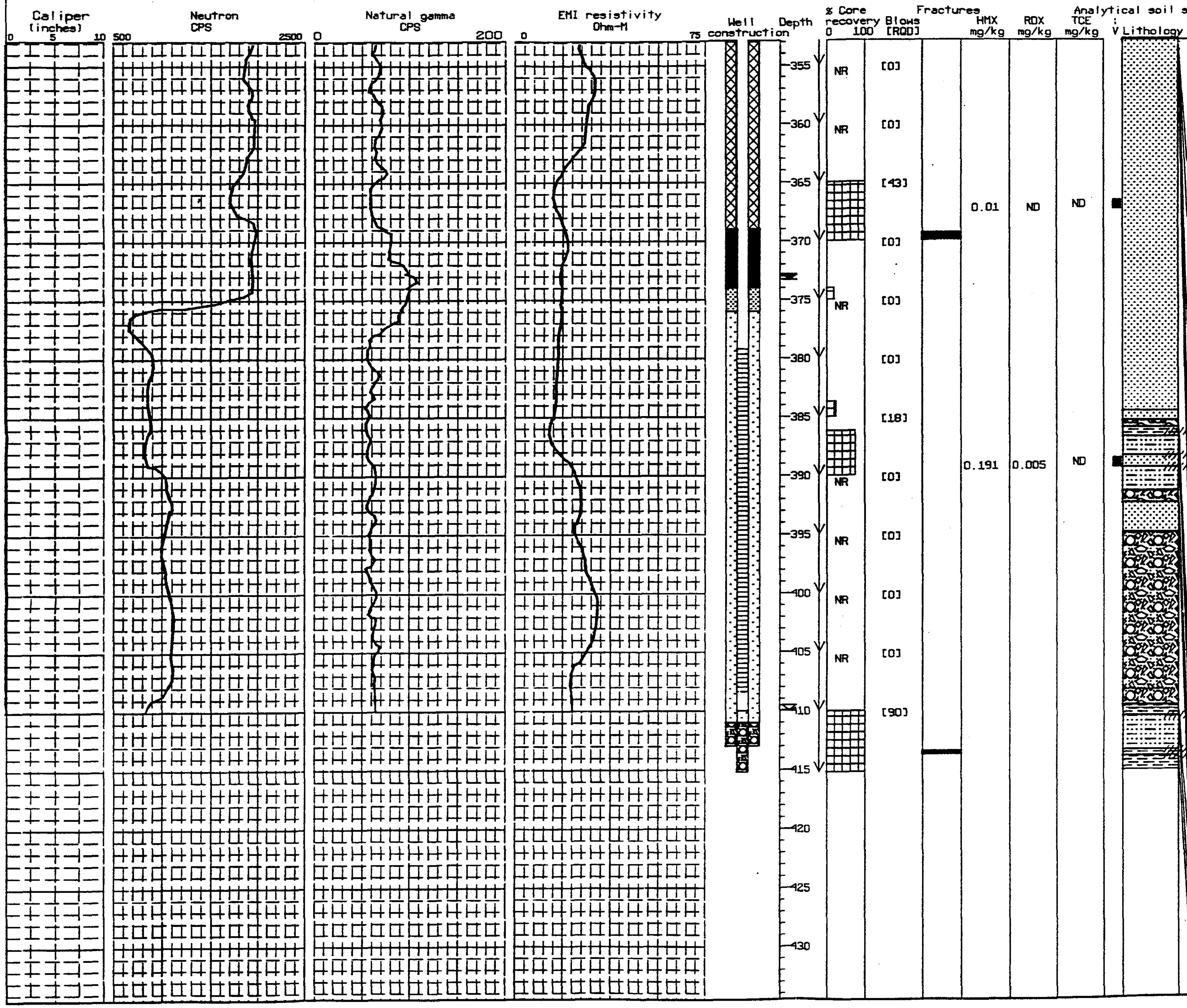
(225.3-245.3) interbedded CLAYSTONES, SANDSTONES, and SILTSTONES, dry to damp, moderately indurated, low porosity, low estimated permeability

light brown silty claystone at 225.3-226 feet; gray claystone at 226-226.3 feet; brown sandy siltstone at 226.3-227.3 feet; light brown silty claystone at 227.3-228.3 feet; light brown silty sandstone with thin subhorizontal laminations at 228.3-231.5 feet; light brown and blue-gray silty claystone at 231.5-232.2 and 232.7-233 feet; sandy siltstone at 232.2-232.7 feet; brown silty sandstone to sandstone with a moderate estimated permeability at 233-235.5 feet; brown-gray, sandy siltstone with moderate estimated fracture permeability at 235.5-239 feet; gray, well indurated silty sandstone with local carbonate cement at 239-240.7 feet; brown sandy siltstone at 240.7-242.5 feet; dark brown, moist, poorly to moderately indurated, silty sandstone with a moderate estimated permeability at 242.5-245.3 feet

[fractures: 225.2/20°/Fe-oxide, 225.5, 225.7, and 226.2/0°/healed, 227/0°/healed with green stains, 227.5-228/16°/yellow, Mn-oxide and bornite-like stains, 228.4-229/subvertical/Fe-oxide, 230.2/33°/yellow stains; fractures with Fe-oxide staining: 230.3/42°, 231.6/0°, 231.7/0°, 232.7/0°, and 231.8-232.2/90°; 237-238/0°/fracture zone Mn-oxide stains, pyrite, and wood fragments; open fractures: 226.3/32° 234.7/43°, 236/64°, 239.2-239.7/90°, 240.4/32°, and 241/40°; 228.3-231.5 and 235.5-239/subhorizontal/bedding]

COMPOSITE LOG: MONITOR WELLS W-827-04 AND W-827-05 (CONTINUED)

SITE 300



Lithologic descriptions and/or remarks

(300.5-312) CLAYSTONE, gray-black, dry, poorly to moderately indurated, 5-10% silt and very fine sand, highly fractured, many slickensides, low estimated primary permeability
    blue-gray silty sandstone interbed with a moderate estimated permeability at 308.8-310.1 feet; green-gray claystone with local white mottling at 310.1-311 feet; 0.5-inch lense of breccia/rip-up clasts at 310.7 feet; dark gray clayey siltstone interbed at 311-312 feet
    [open fractures: 301/38°, 301.5/40° and 20°/intersecting, and 301.7/40° and 23°/intersecting; 310.6/subhorizontal/organic-rich layers; 311.4-311.5/0°/fracture healed with carbonate]

(312-315.3) SANDSTONE, blue-gray, dry, moderately indurated, very fine to fine grained, 10-15% silt, 5-10% clay, micaceous, moderate porosity, moderate estimated permeability
    silica and Fe-oxide filled worm burrows at 314.5-315 feet; coarsens downward below 315 feet

(315.3-323) interbedded SANDSTONE and SILTSTONE, dry, moderately indurated, low estimated permeability
    blue-gray, very fine to fine grained sandstone with 5-10% medium sand, 5-10% silt, <5% clay, and moderate estimated permeability at 315.3-316.9, 317.3-317.6, 318.3-319, and 319.3-319.5 feet; light blue-gray siltstone with 5-10% very fine sand, and 5-10% clay at 316.9-317.3, 317.6-318.3, and 319-319.2 feet; light blue-gray clayey siltstone with 20-30% clay and 5-10% very fine sand at 319.2-319.3 and 319.5-320 feet; crossbedded at 319.5-320 feet

(323-335) SILTY SANDSTONE, gray, dry (?), moderately indurated, very fine grained, 15% silt, cross-bedded, vertically fractured, low to moderate estimated permeability
    siltstone interbeds at 321.3, 322.4, 322.8-323, 323.4, 328.8-329, 329.4-329.7, 331.1, 331.3-331.6, and 331.9-332.2 feet; 20-25% silt at 326.5-327 feet
    [331.4-332.4/90°/slickensides]

(335-336.8) SANDY SILTSTONE, gray, dry, moderately indurated, 20-25% very fine sand, low to moderate estimated permeability
    cross-bedded at 336.3-336.8 feet
    [335.1/28°/open ? fracture]

(336.8-338.3) SILTSTONE, gray-brown, dry, moderately indurated, <2% very fine sand, cross-bedded, low estimated permeability
    0.1 inch voids at 338-338.3 feet
    [upper contact/11°; lower contact/subhorizontal]

(338.3-385.5) SANDSTONE, gray, moist, poorly to moderately indurated, fine to medium grained, 5-10% very fine sand, 2-3% silt, minor biotite, moderate to high estimated permeability
    partially recemented with white silica at 338.5-338.7 feet; pyrite blebs to 0.2 inch, occasional vitreous red and green grains, and mica from cuttings below 341 feet; dry and 5% very fine sand below 365 feet; very poorly to moderately indurated from driller below 370 feet; recovered pieces of medium to coarse grained sandstone, gravelly sandstone, silty sandstone, and siltstone at 380-384.7 feet; dark gray-green silty sandstone interbed at 384.7-385.5 feet
    [338.4/68°/healed fracture with 0.1 inch pyrite blebs, 369.4-370/10°-20°/healed fracture]

(385.5-386.1) CONGLOMERATE, round, aphanitic, volcanic pebbles to 1.5 inches

(386.1-386.9) SILTSTONE, dark gray-black, dry, moderately indurated, 5-10% clay, 1-5% very fine sand, occasional lenses of gravelly sand, very low estimated permeability

(386.9-391.5) SILTY SANDSTONE, gray, dry, moderately indurated, very fine grained, 10-20% silt, low estimated permeability
    dark gray sandstone interbed at 388.5-389.5 feet
    [387.3/18°/bed dipping]

(391.5-392.5) CONGLOMERATE, round pebbles to 1 inch; from driller and cuttings

(392.5-395) SANDSTONE to silty sandstone, blue-gray, medium to coarse grained; from cuttings

(395-409.7) CONGLOMERATE, round, aphantic, volcanic pebbles to 2 inches
    medium to coarse sand below 400 feet; common pyrite blebs on pebble surfaces below 405 feet

(409.7-410.6) SILTSTONE, dark gray with blue-gray mottling, dry, moderately indurated, 5-10% very fine sand, low estimated permeability
    gray-black below 410.5 feet

(410.6-413.5) SILTY SANDSTONE, gray, dry, moderately indurated, very fine grained, 20-25% silt, pyrite blebs to 0.1 inch, tight, low estimated permeability

(413.5-415.2) SILTSTONE, gray, dry, moderately indurated, 5-10% very fine sand, 5% clay, low estimated permeability
    open worm burrows some with pyrite lining at 413.5-414 feet; blue-gray, 5% very fine sand, and tight below 414 feet; worm burrows with silica lining and or filling at 414.3-414.5 feet
    [413.5-413.8/90°/fracture]

TD = 415.2 feet

Appendix C

Appendix C.

Soil and Ground Water

Monitoring Data

Table C-1. Soil analyses from the Open Burn Treatment Facility Closure Area for HE compounds (HMX, RDX, and TNT).

Well	Date	Depth (ft)	HE compounds in µg/g (ppm)		
			HMX	RDX	TNT
W-827-04	June 1990	1.3	<0.001	<0.001	<0.001
	June 1990	5.3	<0.001	<0.001	<0.001
	June 1990	10.3	<0.001	<0.001	<0.001
	June 1990	17.3	<0.001	<0.001	<0.001
	June 1990	20.8	<0.001	<0.001	<0.001
	June 1990	30.3	<0.001	<0.001	<0.001
	June 1990	44.3	<0.001	<0.001	<0.001
	June 1990	50.3	<0.001	<0.001	<0.001
	July 1990	58.8	<0.001	<0.001	<0.001
	July 1990	70.9	<0.001	<0.001	<0.001
	July 1990	82.0	<0.001	<0.001	<0.001
	July 1990	90.0	<0.001	<0.001	<0.001
	July 1990	100.0	<0.001	<0.001	<0.001
	July 1990	113.5	<0.001	<0.001	<0.001
	July 1990	123.5	<0.001	<0.001	<0.001
	July 1990	130.5	<0.001	<0.001	<0.001
	July 1990	140.2	<0.001	<0.001	<0.001
W-827-05	December 1990	321.5	–	<0.001	<0.001
	December 1990	332.5	0.011	<0.001	<0.001
	December 1990	367.0	0.01	<0.001	<0.001
	December 1990	389.0	0.191	0.005	<0.001
829-01	November 1986	2.5	3.1234	0.0145	<0.001
	November 1986	4.8	1.7486	0.9049	<0.001
	November 1986	9.7	0.1413	<0.0011	<0.001
	November 1986	14.7	0.0232	<0.001	<0.001
	November 1986	19.3	0.0186	<0.0004	<0.001
	November 1986	24.4	0.3297	<0.0006	<0.001
	November 1986	30.0	1.1624	0.0174	<0.001
	November 1986	34.3	0.224	0.0522	<0.001
	November 1986	39.8	0.0175	<0.0009	<0.001
	November 1986	44.8	0.0587	<0.0008	<0.001
829-02	December 1986	0.0	3.95	0.074	<0.0008
	December 1986	5.1	0.071	0.045	<0.0008
	December 1986	10.2	0.0006	0.017	<0.0008
	December 1986	15.1	0.006	0.12	<0.0008
	December 1986	20.6	0.026	0.033	<0.0008
	December 1986	25.6	0.026	0.016	<0.0008
	December 1986	29.1	0.0003	0.016	<0.0008
	December 1986	35.6	0.0003	0.0003	<0.0008
	December 1986	40.8	<0.0005	<0.0005	<0.0003

Table C-1. Continued.

			HE compounds in µg/g (ppm)		
Well	Date	Depth (ft)	HMX	RDX	TNT
	December 1986	45.6	<0.0005	<0.0005	<0.0003
	December 1986	50.9	<0.0005	<0.0005	<0.0003
	December 1986	55.6	<0.0005	<0.0005	<0.0003
	December 1986	60.8	<0.0005	<0.0005	<0.0003
	December 1986	69.8	<0.0005	<0.0005	<0.0003
	December 1986	75.7	<0.0005	<0.0005	<0.0003
	December 1986	80.1	<0.0005	<0.0005	<0.0003
	December 1986	85.2	<0.0005	<0.0005	<0.0003
	December 1986	91.5	<0.0005	<0.0005	<0.0003
	December 1986	94.7	<0.0005	<0.0005	<0.0003
	December 1986	100.7	<0.0005	<0.0005	<0.0003
829-03	February 1987	0.0	0.98	0.18	<0.001
	February 1987	4.3	0.022	0.041	<0.001
	February 1987	9.2	0.25	0.045	<0.001
	February 1987	14.3	0.12	0.027	<0.001
	February 1987	19.2	0.58	0.038	<0.001
	February 1987	24.2	<0.0008	<0.0008	<0.001
	February 1987	29.8	<0.0009	<0.0009	<0.001
	February 1987	35.7	<0.0007	<0.0007	<0.001
	February 1987	40.7	<0.0011	<0.001	<0.001
	February 1987	45.5	<0.0005	<0.0005	<0.001
	February 1987	50.7	<0.0004	<0.0004	<0.001
	February 1987	55.3	0.0012	0.0005	<0.001
	February 1987	60.2	<0.0005	<0.0005	<0.001
	February 1987	65.2	<0.0005	<0.0005	<0.001
	February 1987	70.2	0.0066	<0.0005	<0.001
	February 1987	75.4	0.003	<0.0005	<0.001
	February 1987	80.3	<0.0005	<0.0005	<0.001
	February 1987	85.3	<0.0005	<0.0005	<0.001
	February 1987	90.4	<0.0005	<0.0005	<0.001
	February 1987	95.2	0.0059	<0.0005	<0.001
	February 1987	98.5	0.0056	<0.0005	<0.0009
	February 1987	99.8	0.13	0.0097	<0.0009
	February 1987	100.0	0.037	0.037	<0.001
829-04	March 1987	5.0	0.74	0.018	<0.0008
	March 1987	10.4	<0.0005	<0.0005	<0.0008
	March 1987	15.5	<0.0005	<0.0005	<0.0008
	March 1987	19.4	<0.0005	<0.0005	<0.0008
	March 1987	26.8	<0.0005	<0.0005	<0.0008
	March 1987	31.7	<0.0005	<0.0005	<0.0008
	March 1987	37.9	<0.0005	<0.0005	<0.0008
	March 1987	42.3	<0.0005	<0.0005	<0.0008

Table C-1. Continued.

			HE compounds in µg/g (ppm)		
Well	Date	Depth (ft)	HMX	RDX	TNT
	March 1987	48.3	<0.0005	<0.0005	<0.0008
	March 1987	52.6	<0.0005	<0.0005	<0.0008
	March 1987	57.8	<0.0005	<0.0005	<0.0008
	March 1987	64.3	<0.0005	<0.0005	<0.0008
	March 1987	71.5	<0.0005	<0.0005	<0.0008
	March 1987	76.7	<0.0005	<0.0005	<0.0008
	March 1987	81.7	<0.0005	<0.0005	<0.0008
	March 1987	86.6	<0.0005	<0.0005	<0.0008
	March 1987	91.7	<0.0005	<0.0005	<0.0008
	March 1987	96.7	<0.0005	<0.0005	<0.0008
	March 1987	101.0	<0.0005	<0.0005	<0.0008
829-05	January 1987	1.2	0.093	0.038	<0.0005
	January 1987	5.2	<0.0005	<0.0006	<0.0005
	January 1987	10.8	<0.0005	<0.0006	<0.0005
	January 1987	15.4	<0.0005	<0.0006	<0.0005
	January 1987	20.4	<0.0005	<0.0006	<0.0005
	January 1987	25.4	<0.0005	<0.0006	<0.0005
	January 1987	30.8	<0.0005	<0.0006	<0.0005
	January 1987	35.5	<0.0005	<0.0006	<0.0005
	January 1987	40.5	<0.0005	<0.0006	<0.0005
	January 1987	45.5	<0.0005	<0.0006	<0.0005
	January 1987	50.5	<0.0005	<0.0006	<0.0005
	January 1987	54.7	<0.0005	<0.0006	<0.0005
	January 1987	61.5	<0.0005	<0.0006	<0.0005
	January 1987	66.5	<0.0005	<0.0006	<0.0005
	January 1987	72.3	<0.0005	<0.0006	<0.0005
	January 1987	76.9	<0.0005	<0.0006	<0.0005
	January 1987	81.7	<0.0005	<0.0006	<0.0005
	January 1987	87.2	<0.0005	<0.0006	<0.0005
829-06	January 1987	3.7	0.81	<0.005	<0.008
	January 1987	8.5	<0.005	<0.005	<0.008
	January 1987	13.9	<0.005	<0.005	<0.008
	January 1987	18.9	<0.005	<0.005	<0.008
	January 1987	23.1	<0.005	<0.005	<0.008
	January 1987	27.9	<0.005	<0.005	<0.008
	January 1987	33.1	<0.005	<0.005	<0.008
	January 1987	37.7	<0.005	<0.005	<0.008
	January 1987	43.1	<0.005	<0.005	<0.008
	January 1987	48.2	<0.005	<0.005	<0.008
	January 1987	52.7	<0.005	<0.005	<0.008
	January 1987	58.8	<0.005	<0.005	<0.008
	January 1987	67.4	<0.005	<0.005	<0.008

Table C-1. Continued.

Well	Date	Depth (ft)	HE compounds in µg/g (ppm) HMX	 RDX	 TNT
	January 1987	73.9	<0.005	<0.005	<0.008
	January 1987	79.2	<0.005	<0.005	<0.008
	January 1987	84.9	<0.005	<0.005	<0.008
	January 1987	89.7	<0.005	<0.005	<0.008
	January 1987	95.4	<0.005	<0.005	<0.008
	January 1987	99.2	<0.005	<0.005	<0.008
829-09	August 1990	2.6	0.016	<0.001	<0.001
	August 1990	4.2	0.061	0.011	<0.001
829-10	August 1990	2.6	<0.001	<0.001	<0.001
	August 1990	5.2	<0.001	<0.001	<0.001
829-11	August 1990	4.8	0.451	<0.001	<0.001
	August 1990	10.9	<0.001	<0.001	<0.001
829-12	August 1990	2.5	0.039	<0.001	<0.001
	August 1990	6.5	0.003	<0.001	<0.001
829-13	August 1990	6.0	<0.001	<0.001	<0.001
	August 1990	10.2	<0.001	<0.001	<0.001
829-14	August 1990	8.0	0.032	<0.001	<0.001

Notes:
All analyses performed by HPLC Laboratory, LLNL.

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Table C-2. Soil analyses (mg/kg) for volatile organic compounds from the Burn

Borehole Date	Depth (ft)	PCE	TCE	1,1-DCE	Total 1,2-DCE	1,1,1-TCA	1,1-DCA	1,2-DCA
829-01								
17-OCT-86	2.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17-OCT-86	4.7	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17-OCT-86	9.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17-OCT-86	14.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17-OCT-86	14.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17-OCT-86	24.9	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17-OCT-86	34.0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17-OCT-86	34.8	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17-OCT-86	39.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
17-OCT-86	44.4	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
829-03								
05-JAN-87	4.8	<0.0002	0.028	<0.0002	0.0006	<0.0002	<0.0002	<0.0002
05-JAN-87	9.8	<0.0002	0.0015	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
05-JAN-87	14.8	<0.0002	0.0004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
05-JAN-87	24.7	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
05-JAN-87	29.8	<0.0002	0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
06-JAN-87	35.5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
06-JAN-87	40.5	<0.0002	0.0015	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
829-07								
08-JAN-87	4.6	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.0022
08-JAN-87	9.5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
08-JAN-87	14.6	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
08-JAN-87	19.7	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
08-JAN-87	24.5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
08-JAN-87	29.5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
08-JAN-87	34.5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
08-JAN-87	39.4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
08-JAN-87	44.4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
08-JAN-87	49.4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
829-09								
13-AUG-90	2.8	<0.0002	0.028	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
13-AUG-90	4.4	<0.0002	0.001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
829-10								
13-AUG-90	2.8	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
13-AUG-90	5.4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
829-11								
13-AUG-90	3.5	<0.0002	0.0004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
13-AUG-90	10.7	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
829-12								
13-AUG-90	6.6	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
829-13								
13-AUG-90	2.5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
13-AUG-90	10.4	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
829-14								
13-AUG-90	2.0	-	-	-	-	-	-	-
13-AUG-90	8.3	-	-	-	-	-	-	-
13-AUG-90	8.5	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002

Treatment Facility Closure Area reported by October 3, 1990.

Borehole Date	Depth (ft)	Carbon Tet	Chloro-form	Freon 113	Total Fuel Hydrocarbons	Benzene	Toluene	Xylenes
829-01								
17-OCT-86	2.5	<0.2	<0.2	-	-	-	<0.2	-
17-OCT-86	4.7	<0.2	<0.2	-	-	-	<0.2	-
17-OCT-86	9.5	<0.2	<0.2	-	-	-	<0.2	-
17-OCT-86	14.5	<0.2	<0.2	-	-	-	<0.2	-
17-OCT-86	14.5	<0.2	<0.2	-	-	-	<0.2	-
17-OCT-86	24.9	<0.2	<0.2	-	-	-	<0.2	-
17-OCT-86	34.0	<0.2	<0.2	-	-	-	<0.2	-
17-OCT-86	34.8	<0.2	<0.2	-	-	-	<0.2	-
17-OCT-86	39.5	<0.2	<0.2	-	-	-	<0.2	-
17-OCT-86	44.4	<0.2	<0.2	-	-	-	<0.2	-
829-03								
05-JAN-87	4.8	<0.0002	0.0004	<0.0002	-	-	-	-
05-JAN-87	9.8	<0.0002	<0.0002	<0.0002	-	-	-	-
05-JAN-87	14.8	<0.0002	0.0007	<0.0002	-	-	-	-
05-JAN-87	24.7	<0.0002	0.0009	<0.0002	-	-	-	-
05-JAN-87	29.8	<0.0002	<0.0002	<0.0002	-	-	-	-
06-JAN-87	35.5	<0.0002	<0.0002	<0.0002	-	-	-	-
06-JAN-87	40.5	<0.0002	<0.0002	<0.0002	-	-	-	-
829-07								
08-JAN-87	4.6	<0.0002	0.0007	<0.0002	-	-	-	-
08-JAN-87	9.5	<0.0002	<0.0002	<0.0002	-	-	-	-
08-JAN-87	14.6	<0.0002	<0.0002	<0.0002	-	-	-	-
08-JAN-87	19.7	<0.0002	<0.0002	<0.0002	-	-	-	-
08-JAN-87	24.5	<0.0002	<0.0002	<0.0002	-	-	-	-
08-JAN-87	29.5	<0.0002	<0.0002	<0.0002	-	-	-	-
08-JAN-87	34.5	<0.0002	<0.0002	<0.0002	-	-	-	-
08-JAN-87	39.4	<0.0002	<0.0002	<0.0002	-	-	-	-
08-JAN-87	44.4	<0.0002	<0.0002	<0.0002	-	-	-	-
08-JAN-87	49.4	<0.0002	<0.0002	<0.0002	-	-	-	-
829-09								
13-AUG-90	2.8	<0.0002	<0.0002	<0.0002	-	-	-	-
13-AUG-90	4.4	<0.0002	<0.0002	<0.0002	-	-	-	-
829-10								
13-AUG-90	2.8	<0.0002	<0.0002	<0.0002	-	-	-	-
13-AUG-90	5.4	<0.0002	<0.0002	<0.0002	-	-	-	-
829-11								
13-AUG-90	3.5	<0.0002	<0.0002	<0.0002	-	-	-	-
13-AUG-90	10.7	<0.0002	<0.0002	<0.0002	-	-	-	-
829-12								
13-AUG-90	6.6	<0.0002	<0.0002	<0.0002	-	-	-	-
829-13								
13-AUG-90	2.5	<0.0002	<0.0002	<0.0002	-	-	-	-
13-AUG-90	10.4	<0.0002	<0.0002	<0.0002	-	-	-	-
829-14								
13-AUG-90	2.0	-	-	-	<1	-	-	-
13-AUG-90	8.3	-	-	-	<1	-	-	-
13-AUG-90	8.5	<0.0002	<0.0002	<0.0002	-	-	-	-

Notes:
- Indicates no analysis performed for this compound.

Table C-3. Burn Treatment Facility Closure Area soil analyses for metals in

Location Date Sampled	Depth (ft)	Sb	As	Ba	Be	Cd	Cr	Co	Cu
STLC		15	5.0	100	0.75	1.0	560	80	25
829-01									
17-OCT-86	2.5	0.1	0.05	28	<0.01	0.11	0.06	0.45	3.7
17-OCT-86	4.7	<0.1	0.02	5	<0.01	0.06	0.02	<0.05	0.18
17-OCT-86	9.5	<0.1	0.02	1.9	<0.01	<0.01	<0.02	<0.05	0.05
17-OCT-86	14.5	<0.1	<0.01	0.6	<0.01	<0.01	<0.02	<0.05	<0.08
17-OCT-86	24.9	<0.1	<0.01	0.4	<0.01	<0.01	<0.02	<0.05	0.03
17-OCT-86	34.0	<0.1	0.04	0.2	<0.01	<0.01	<0.02	<0.05	<0.02
17-OCT-86	34.8	<0.1	0.01	0.9	<0.01	<0.01	<0.02	<0.05	0.03
17-OCT-86	39.5	<0.1	0.03	1.8	<0.01	0.05	0.02	0.4100	0.18
17-OCT-86	44.4	<0.1	0.01	2.5	<0.01	<0.01	<0.02	0.13	0.15
829-09									
13-AUG-90	2.8	<0.2	<0.02	5	<0.01	<0.05	<0.05	0.1	0.27
13-AUG-90	4.4	<0.2	0.05	2.4	<0.01	<0.05	0.05	0.05	0.29
829-10									
13-AUG-90	2.8	<0.2	<0.02	1.4	<0.01	<0.05	<0.05	<0.05	0.17
13-AUG-90	5.4	<0.2	0.05	3.2	0.02	<0.05	0.05	0.4100	0.53
829-11									
13-AUG-90	3.5	<0.2	0.04	4.1	<0.01	<0.05	<0.05	0.29	0.65
13-AUG-90	10.7	<0.2	0.02	2.6	<0.01	<0.05	0.05	0.16	0.27
829-12									
13-AUG-90	6.6	<0.2	0.07	0.96	<0.01	<0.05	<0.05	<0.05	0.09
829-13									
13-AUG-90	2.5	<0.2	0.04	4.5	<0.01	<0.05	<0.05	0.36	0.58
13-AUG-90	10.4	<0.2	<0.02	3.8	<0.01	<0.05	<0.05	0.26	0.14
829-14									
13-AUG-90	8.5	<0.2	<0.02	1.2	<0.01	<0.05	<0.05	<0.05	0.32

mg/L (ppm) by the CAM Wet procedure for STLC reported by October 2, 1990.

Pb	Hg	Mo	Ni	Se	Ag	Tl	V	Zn	Location
5.0	0.2	350	20	1.0	5	7.0	24	250	
1.3	<0.001	<0.1	0.39	0.02	<0.01	<0.1	0.54	11	829-01
0.3	<0.001	<0.1	<0.05	<0.01	<0.01	<0.1	0.37	0.15	
0.3	<0.001	<0.1	<0.05	<0.01	<0.01	<0.1	<0.2	0.31	
<0.1	<0.001	<0.1	0.22	<0.01	<0.01	<0.1	<0.2	0.07	
<0.1	<0.001	<0.1	0.3	<0.01	<0.01	<0.1	<0.2	0.05	
<0.1	<0.001	<0.1	<0.05	<0.01	<0.01	<0.1	<0.2	0.02	
<0.1	<0.001	<0.1	<0.05	<0.01	<0.01	<0.1	<0.2	0.05	
<0.1	<0.001	<0.1	0.26	0.01	<0.01	<0.1	<0.2	0.12	
<0.1	<0.001	<0.1	0.17	<0.01	<0.01	<0.1	<0.2	0.08	
<0.2	<0.005	<0.2	<0.1	<0.02	<0.05	<0.2	0.49	0.25	829-09
<0.2	<0.005	<0.2	0.1	<0.02	<0.05	<0.2	0.4	0.37	
<0.2	<0.005	<0.2	<0.1	<0.02	<0.05	<0.2	0.68	0.18	829-10
<0.2	<0.005	<0.2	0.3	<0.02	<0.05	<0.2	1.1	0.56	
<0.2	<0.005	<0.2	0.3	<0.02	<0.05	<0.2	1	0.75	829-11
<0.2	<0.005	<0.2	<0.1	<0.02	<0.05	<0.2	0.47	0.4	
<0.2	<0.005	<0.2	<0.1	<0.02	<0.05	<0.2	1.2	0.14	829-12
0.5	<0.005	<0.2	0.4	<0.02	<0.05	<0.2	1.4	0.4100	829-13
<0.2	<0.005	<0.2	0.1	<0.02	<0.05	<0.2	0.64	0.43	
<0.2	<0.005	<0.2	<0.1	<0.02	<0.05	<0.2	0.76	0.4	829-14

Notes:

Sb	Antimony
As	Arsenic
Ba	Barium
Be	Beryllium
Cd	Cadmium
Cr	Chromium
Co	Cobalt
Cu	Copper
Pb	Lead
Hg	Mercury
Mo	Molybdenum
Ni	Nickel
Se	Selenium
Ag	Silver
Tl	Thallium
V	Vanadium
Zn	Zinc

Table C-4. Water analyses (ppm) and Maximum Contaminant Levels (MCLs) for metals

Installation Date Sampled	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium total	Chromium hexavalent
MCL	*	0.05	1.0	*	0.01	0.05	*
W-827-05							
13-Aug-91	-	0.003	<0.05	-	<0.0005	<0.005	-
28-Aug-91	-	0.003	<0.05	-	<0.0005	<0.005	-
11-Sep-91	-	<0.002	<0.05	-	<0.0005	<0.005	-
25-Sep-91	-	0.003	<0.05	-	<0.0005	<0.005	-
W-829-06							
04-Dec-92	-	0.0062	0.058	-	<0.0005	<0.01	-
W-829-08							
08-Dec-87	-	-	-	-	-	-	-
25-Oct-88	-	-	-	-	-	-	-
04-Jun-91	-	-	-	-	-	-	-
19-Jan-93	<0.2	0.0039	-	<0.01	<0.05	<0.05	-

in ground water samples from selected locations recorded by April 14, 1993.

Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Silver	Installation Zinc
*	*	0.05	*	0.002	*	0.01	0.05	5.0
								W-827-05
<0.05	<0.1	<0.002	0.24	<0.0005	–	<0.002	<0.05	<0.05
<0.05	<0.1	<0.002	0.3	<0.0005	–	<0.002	<0.05	<0.05
<0.05	<0.1	<0.002	0.22	<0.0005	–	<0.002	<0.05	<0.05
<0.05	<0.1	<0.002	0.26	<0.0005	–	<0.002	<0.05	0.11
								W-829-06
<0.05	1	<0.002	0.31	<0.0002	–	0.2	<0.05	<0.05
								W-829-08
<0.02	1.5	–	0.02	–	–	–	–	<0.01
<0.02	0.15	–	<0.01	–	–	–	–	0.06
<0.05	<0.1	–	<0.05	–	–	–	–	<0.05
<0.05	–	<0.2	–	<0.0002	<0.1	0.37	<0.05	<0.05

Notes:
All analyses performed by Brown and Caldwell, Emeryville, Calif.

– Indicates no analysis performed for this compound.
* Indicates Primary Standard MCL has not been established for this metal.

Table C-5. Ground water analyses for HE compounds (HMX, RDX, and TNT) from selected locations recorded by April 14, 1993.

Location	Date	Notes	HE compounds in µg/L (ppb)		
			HMX	RDX	TNT
W-827-05					
	13-Aug-91		<20	<20	<30
	28-Aug-91		<20	<20	<30
	11-Sep-91		<20	<20	<30
	25-Sep-91		<20	<30	<30
	06-Dec-91	ab	<0.8	<0.7	<0.5
	06-Dec-91	b	<20	<30	<30
	05-Feb-92		<20	<30	<30
	11-May-92		<20	<30	<30
	29-Jul-92		<20	<30	<30
	19-Oct-92		<20	<30	<30
	20-Jan-93		<20	<30	<30
W-829-06					
	04-Dec-92		<20	<30	<30
	19-Jan-93		<20	<30	<30
W-829-08					
	04-May-87		<20	<20	<20
	06-Jan-88	c	<8	<20	<20
	06-Jan-88	c	<8	<20	<20
	21-Mar-88		<15	<20	<15
	27-Jun-88		<20	<20	<20
	25-Oct-88		<20	<30	<40
	10-Feb-89		<20	<20	<20
	12-Apr-89		<20	<20	<20
	13-Jul-89		<30	<30	<30
	12-Oct-89		<10	<10	<10
	18-Jan-90		<15	<30	<30
	17-Apr-90		<15	<20	<30
	13-Jul-90		<20	<40	<40
	24-Oct-90		<20	<30	<30
	06-Feb-91		<20	<30	<30
	04-Jun-91		<20	<30	<30
	16-Aug-91		<20	<20	<30
	10-Dec-91	ab	<0.8	<0.7	<0.5
	10-Dec-91	b	<20	<30	<30
	30-Jun-92		<20	<30	<30
	04-Dec-92		<20	<30	<30
	19-Jan-93		<20	<30	<30

Notes:

Unless otherwise noted analyses performed by HPLC Laboratory, LLNL.

a Analysis performed by Environmental Science & Engineering, Inc., Gainesville,

Table C-5. Ground water analyses for HE compounds (HMX, RDX, and TNT) from selected locations recorded by April 14, 1993.

Location	Date	Notes	HE compounds in µg/L (ppb)		
			HMX	RDX	TNT

Florida.

b Interlaboratory duplicate sample.

c Intralaboratory duplicate sample.

Table C-6. Ground water analyses (µg/L) for volatile organic compounds from

Location Date	Notes*	1,1 DCE	cis-1,2 DCE	trans-1,2 DCE	Total 1,2 DCE	TCE	PCE	1,1 DCA
W-827-05								
13-AUG-91		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
28-AUG-91		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
11-SEP-91		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
25-SEP-91		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
06-DEC-91		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
05-FEB-92		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
11-MAY-92		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
29-JUL-92		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
19-OCT-92		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
20-JAN-93		<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
W-829-06								
04-DEC-92		<5	7.9	<5	7.9	700	<5	<5
19-JAN-93		<5	6.8	<5	6.8	750	<5	<5
W-829-08								
22-APR-87		<0.5	-	-	<0.5	5.2	<0.5	<0.5
08-DEC-87		<1	-	-	<1	<1	<1	<1
14-MAR-88		<0.5	-	-	<0.5	5.4	<0.5	<0.5
27-JUN-88		<0.5	-	-	<0.5	2.1	<0.5	<0.5
25-OCT-88		<0.5	-	-	<0.5	4.5	<0.5	<0.5
10-FEB-89		<0.5	-	-	<0.5	<0.5	<0.5	<0.5
12-APR-89		<0.5	-	-	<0.5	3.4	<0.5	<0.5
13-JUL-89		<0.5	-	-	<0.5	5.8	<0.5	<0.5
12-OCT-89		<0.5	<0.5	<0.5	<0.5	4.9	<0.5	<0.5
18-JAN-90		<0.5	<0.5	<0.5	<0.5	4.2	<0.5	<0.5
17-APR-90		<0.5	<0.5	<0.5	<0.5	3	<0.5	<0.5
13-JUL-90		<0.5	<0.5	<0.5	<0.5	2.5	<0.5	<0.5
24-OCT-90		<0.5	<0.5	<0.5	<0.5	3.4	<0.5	<0.5
08-FEB-91		<0.5	<0.5	<0.5	<0.5	2.5	<0.5	<0.5
04-JUN-91		<0.5	<0.5	<0.5	<0.5	4	<0.5	<0.5
16-AUG-91	b	<0.5	<0.5	<0.5	<0.5	4.2	<0.5	<0.5
16-AUG-91	ab	<0.2	<0.4	<0.4	<0.4	3.9	<0.5	<0.4
10-DEC-91		<0.5	<0.5	<0.5	<0.5	5.6	<0.5	<0.5
30-JUN-92	b	<0.5	<0.5	<0.5	<0.5	7.9	<0.5	<0.5
30-JUN-92	ab	<0.2	<0.4	<0.4	<0.4	5.1	<0.5	<0.4
04-DEC-92		<0.5	<0.5	<0.5	<0.5	7.2	<0.5	<0.5
19-JAN-93		<0.5	<0.5	<0.5	<0.5	10	<0.5	<0.5

selected locations recorded by April 14, 1993.

1,2 DCA	1,1,1 TCA	Chloro- form	Freon 11	Freon 113	Methylene Chloride	Location
						W-827-05
<0.5	<0.5	<0.5	<0.5	<0.5	<2	
<0.5	<0.5	<0.5	<0.5	<0.5	<2	
<0.5	0.7	<0.5	<0.5	<0.5	<2	
<0.5	<0.5	<0.5	<0.5	<0.5	<2	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
						W-829-06
<5	<5	<5	<5	<10	<5	
<5	<5	<5	<5	<10	<5	
						W-829-08
<0.5	<0.5	<0.5	<0.5	1.2	<0.5	
<1	<1	<1	<1	–	<1	
<0.5	<0.5	<0.5	<0.5	0.9	<0.5	
<0.5	<0.5	<0.5	<0.5	1.2	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.3	<0.5	<0.5	<0.4	<0.6	<2	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.3	<0.5	<0.5	<0.4	<0.6	<2	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	

Notes:
- Indicates no analysis performed for this compound.
* Unless otherwise indicated, all analyses performed by Brown and Caldwell, Emeryville, Calif.
a Analysis performed by Clayton Environmental Consultants, Pleasanton, Calif. (formerly McKesson Environmental Services).
b Interlaboratory duplicate sample.

Table C-7. Probable background concentrations of metals and metalloids in soil at Site 300 compared to worldwide concentrations in soil and rock.

Element	Site 300 subsurface soil (mg/kg)	Site 300 surface soil (mg/kg)	Worldwide shale[a] (mg/kg)	Worldwide sandstone[b] (mg/kg)	Worldwide soil, uncultivated[b] (mg/kg)
Antimony	d	1.0[c]	1.5	0.01	NA[d]
Arsenic	0.5–6.0	0.4–11.0	13.0	1-4.3	6.7–13
Barium	52–390	55.0–330.0	580.0	38–170	86–740
Beryllium	0.1–1.4	0.1–1.2	3.0	0.8	0.76–1.3
Cadmium	0.1–0.3	0.1–1.4	0.3	NA	NA
Chromium (Total)	9.6–6.5	7.0–60.0	90.0	2.0–39.0	11.0–78
Cobalt	6–18	4.0–19.0	19.0	1.6–7.4	1.0–14
Copper	13–56	8.0–39.0	45.0	1.2–8.4	8.7–33
Fluoride	d	d	740.0	9.8–120	NA
Lead	1–30	6.0–110	20.0	5.0–17	2.6–25
Mercury	0.01–0.1	0.02–0.2	0.4	0.008–0.016	0.045–0.16
Molybdenum	2–7	5.0[e]	2.6	0.2	NA
Nickel	8–60	6.0–80.0	68.0	1.2–18	4.4–23
Selenium	d	ND[f]	0.6	0.09–0.11	0.27–0.73
Silver	d	2.5[g]	0.07	0.01	NA
Thallium	3.6–14	ND[f]	1.4	0.82	NA
Uranium	d	h	3.7	0.45	1
Vanadium	20–93	20.0–130.0	130.0	5.3–38	15–110
Zinc	21–91	22.0–81.0	95.0	5.2–31	25–67

Note: Footnotes appear on next page.

Table C-7. (Continued).

[a] Faure (1991) data. Shales are composed of claystones and siltstones.

[b] Summarized by McKenzie (1992) from worldwide data compiled by Faure (1991) and United States data compiled by Brownlow (1979).

[c] Antimony has only been detected in six surface soil samples. The lowest limit of detection was 1.0 mg/kg; the highest measured concentration was 2.0 mg/kg. Data are too limited to determine its presence at background levels.

[d] NA - no applicable information available.

[e] Molybdenum was detected only once in surface soil. The lowest limit of detection was 1.0 mg/kg. Data are too limited to determine its presence at background levels.

[f] ND - not detected in any surface soil samples. The lowest limit of detection was 0.4 mg/kg (selenium) and 1.0 mg/kg (thallium).

[g] Silver was detected in only three surface soil samples. The lowest limit of detection was 0.4 mg/kg; the maximum measured concentration was 5.0 mg/kg. Data are too limited to determine its presence at background levels.

[h] Uranium data expressed as activity levels (pCi/g) are: ^{234}U, 1.8×10^{0}; ^{235}U, 4.0×10^{-1}; ^{238}U, 1.0×10^{0}.

Table C-8. Ground Water Elevations for Monitor Wells W-827-04, W-827-05, W-829-06, W-829-08, and W-829-15.

Location Date of Measurement	Depth to Water (ft)	Water Elevation (ft/MSL)	Notes
W-827-04			
10/10/90			DRY
11/12/90			DRY
12/03/90			DRY
01/17/91			DRY
02/07/91			DRY
03/08/91			DRY
04/04/91			DRY
05/06/91			DRY
06/11/91			DRY
07/10/91			DRY
08/07/91			DRY
09/09/91			DRY
10/07/91			DRY
11/27/91			DRY
12/05/91			DRY
01/10/92			DRY
02/03/92			DRY
03/31/92			DRY
07/14/92			DRY
10/02/92			DRY
01/26/93			DRY
04/08/93			DRY
07/19/93			DRY
10/13/93			DRY
01/06/94			DRY
04/05/94			DRY
07/06/94			DRY
10/12/94			DRY
01/18/95			DRY
10/09/95	308.09	725.54	
01/10/96			DRY
04/09/96			DRY
07/10/96			DRY
10/04/96			DRY
01/09/97			DRY
W-827-05			
08/07/91			NM
09/09/91			NM
10/07/91	377.20	656.68	
11/27/91	377.03	656.85	
12/05/91	377.26	656.62	
01/10/92	377.55	656.33	
02/03/92	377.15	656.73	
03/31/92	377.04	656.84	
07/14/92	377.61	656.27	
10/02/92	377.78	656.10	
01/26/93	378.12	655.76	
04/08/93	378.40	655.48	
07/19/93	378.50	655.38	
10/13/93	378.45	655.43	
01/06/94	378.83	655.05	
04/05/94	378.76	655.12	
07/06/94	378.92	654.96	
10/12/94	378.91	654.97	
01/18/95	379.45	654.43	
04/11/95			NM
07/10/95	379.47	654.41	
10/09/95	379.64	654.24	
01/10/96	379.92	653.96	
W-827-05 (continued)			
04/09/96	379.87	654.01	
07/10/96	379.85	654.03	
10/04/96	379.85	654.03	
01/09/97	380.49	653.39	
W-829-06			
03/03/88	95.92	976.37	
04/06/88	95.85	976.44	
05/04/88	95.73	976.56	
06/02/88	95.83	976.46	
07/07/88	95.91	976.38	
08/05/88	95.92	976.37	
09/06/88	95.78	976.51	
10/10/88	96.05	976.24	
11/04/88	96.31	975.98	
11/29/88	96.44	975.85	
01/12/89	96.46	975.83	
02/08/89	96.26	976.03	
03/02/89	95.78	976.51	
04/14/89	96.25	976.04	
05/12/89	96.07	976.22	
06/08/89	96.01	976.28	
07/07/89	96.28	976.01	
08/08/89	96.45	975.84	
09/06/89	95.94	976.35	
10/09/89	96.27	976.02	
11/09/89	96.48	975.81	
12/08/89	96.48	975.81	
01/11/90	96.29	976.00	
01/31/90	96.30	976.00	
03/06/90	96.57	975.72	
04/02/90	96.49	975.80	
05/01/90	96.40	975.89	
06/05/90	96.45	975.84	
07/05/90	96.70	975.59	
08/02/90	96.39	975.90	
09/10/90	96.36	975.93	
10/10/90	96.51	975.78	
11/12/90	96.73	975.56	
12/03/90	96.86	975.43	
01/17/91	96.82	975.47	
02/08/91	96.82	975.47	
03/08/91	96.71	975.58	
04/11/91	96.77	975.52	
05/10/91	96.63	975.66	
06/11/91	96.65	975.64	
07/23/91	96.63	975.66	
08/07/91	96.80	975.49	
09/11/91	96.76	975.53	
10/07/91	96.78	975.51	
11/27/91	98.89	973.40	
12/05/91	96.89	975.40	
01/09/92	97.00	975.29	
03/31/92	96.81	975.48	
07/14/92	96.88	975.41	
10/02/92	96.58	975.71	
01/26/93	96.81	975.48	
04/08/93	96.48	975.81	
07/19/93	95.90	976.39	
10/13/93	95.56	976.74	
10/28/93	95.40	976.89	
01/06/94			NM

Table C-8. continued.

Location Date of Measurement	Depth to Water (ft)	Water Elevation (ft/MSL)	Notes
W-829-06 (continued)			
04/05/94	95.61	976.68	
07/06/94	95.37	976.92	
10/12/94	95.36	976.93	
01/18/95	95.83	976.46	
04/06/95	95.20	977.09	
05/31/95	94.92	977.37	PS
07/10/95	94.87	977.42	
10/06/95	94.78	977.51	
01/10/96	95.26	977.03	
04/11/96	94.73	977.56	
07/10/96	94.53	977.76	
10/14/96	94.77	977.52	
01/16/97	95.03	977.26	
W-829-08			
03/03/88	98.08	976.67	
04/06/88	98.07	976.68	
05/04/88	97.80	976.95	
06/02/88	98.08	976.67	
07/07/88	98.08	976.67	
08/05/88	98.07	976.68	
09/06/88	97.98	976.77	
10/10/88	98.17	976.58	
11/04/88	98.43	976.32	
11/29/88	98.59	976.16	
01/12/89	98.57	976.18	
02/08/89	98.30	976.45	
03/02/89	97.84	976.91	
04/12/89	97.89	976.86	
05/12/89	98.16	976.59	
06/08/89	98.03	976.72	
07/07/89	98.33	976.42	
08/08/89	98.25	976.50	
09/06/89	97.93	976.82	
10/09/89	98.38	976.37	
11/09/89	98.63	976.12	
12/08/89	98.57	976.18	
01/11/90	98.44	976.31	
01/31/90	98.30	976.40	
03/06/90	98.61	976.14	
04/02/90	98.50	976.25	
05/01/90	98.00	976.75	
06/05/90	98.46	976.29	
07/05/90	98.67	976.08	
08/02/90	98.45	976.30	
09/10/90	98.40	976.35	
10/10/90	98.51	976.24	
11/12/90	98.82	975.93	
12/03/90	98.90	975.85	
01/17/91	98.84	975.91	
02/07/91	98.86	975.89	
03/08/91	98.65	976.10	
04/11/91	98.79	975.96	
05/10/91	98.60	976.15	
06/11/91	98.63	976.12	
07/23/91	98.65	976.10	
08/07/91	98.82	975.93	
09/10/91	98.77	975.98	
10/07/91	98.78	975.97	
11/27/91	98.90	975.85	
12/05/91	98.97	975.78	
W-829-08 (continued)			
01/09/92	99.00	975.75	
03/31/92	98.90	975.85	
07/14/92	98.94	975.81	
10/02/92	98.83	975.92	
01/26/93	98.94	975.81	
04/08/93	98.65	976.10	
07/19/93	98.10	976.65	
10/13/93	97.78	976.97	
01/05/94			NM
04/05/94	97.75	977.00	
07/06/94	97.57	977.18	
10/12/94	97.42	977.33	
01/18/95	97.78	976.97	
04/06/95	97.37	977.38	
05/31/95	97.09	977.66	PS
06/02/95	97.09	977.66	PS
07/10/95	97.41	977.34	
10/06/95	97.07	977.68	
01/10/96			DRY
04/11/96	96.99	977.76	
07/10/96	96.65	978.10	
10/14/96			
01/16/97	97.19	977.56	
W-829-15			
03/10/95	338.68	695.32	
05/04/95			NM
06/02/95	339.70	694.30	
07/10/95	339.42	694.58	
08/01/95	339.53	694.47	
09/06/95	340.09	693.91	
10/09/95	340.18	693.82	
11/02/95	340.18	693.82	
12/06/95	340.09	693.91	
01/10/96	340.25	693.75	
02/01/96	340.03	693.97	
03/01/96	340.34	693.66	
04/09/96	340.15	693.85	
05/01/96	330.15	703.85	
06/05/96	330.56	703.44	
07/10/96	339.72	694.28	
08/06/96	339.74	694.26	
09/05/96	339.84	694.16	
10/14/96	340.04	693.96	DRY
11/08/96	340.22	693.78	
12/09/96	339.78	694.22	
01/09/97	340.30	693.70	

Notes:

ABD	Abandoned well.
AD	Drilling of adjacent new wells disturbed water level.
BS	Water detected below bottom of screened interval.
DRY	Well dry at time of time of measurement.
ME	Measuring error suspected.
NM	Not measured.
PD	Predevelopment measurement.
PS	Measurement taken just before sampling.
PT	Pump test interfered with measurement.
WE	Well equilibrium suspect.
WR	Well recovery.

Appendix D

Appendix D.

Technical Specifications

Technical Specifications

D.1 Construction Materials and Methods

Materials for the cover system will be either imported from offsite sources or derived from onsite borrow areas as identified in the construction drawings. The federal government procurement process does not allow LLNL to list specific sources for imported materials in the specifications. However, the CM will utilize nearby quarries for the clay layer that meet material requirements set forth in the following specifications and construction drawings.

D.1.1 Foundation Layer

The foundation layer for the waste pit cover will consist of materials derived from the excavation for the Building 801 Contained Firing Facility (CFF). If additional foundation material is needed, it will be taken from the barrier mound located between the HE Open Burn Treatment Facility and the hazardous waste storage shed. The existing fill materials used to construct the pits and the mound are derived from the same borrow area. These borrow materials must be free of roots, debris, and clods and/or rocks larger than 4 in. in diameter. The foundation layer will fill the pits and will be a minimum of 1 ft compacted thickness (Construction Drawing D-2 in section D.5). Approximately 2,000 yd^3 of uncompacted material will be required to construct the foundation layer.

Based upon modified Proctor maximum density/optimum moisture content and saturated flexible-wall permeameter test correlations, the foundation layer shall be compacted to the following modified Proctor compaction specification within the corresponding moisture content ranges:

Modified Proctor (%)	Moisture Content Range (%)
95 or greater	optimum moisture content to optimum moisture content + 4%

All compaction shall be accomplished by the procedures outlined in Appendix D.2, "Compaction Methods."

D.1.2 Geosynthetic Drainage and Low-Permeability Layers

The proposed geosynthetic drainage layer for the HE Open Burn Treatment Facility closure is 0.28-in-thick geocomposite material. The low-permeability layers consist of a 0.18-in-thick bentonite-impregnated geotextile overlain by a 60-mil-thick, high-density, polyethylene layer. Approximately 20,000 ft^2 of each of these materials will be required. The specifications in this section describe the geosynthetic, geotextile, and HDPE manufacturing and installation requirements. The supply and installation of these materials shall be in strict accordance with the engineer's specifications and construction drawings and will be subject to the terms and conditions of the contract.

D.1.2.1 Manufacturer's Experience

The manufacturer of the lining materials described herein must have previously demonstrated the ability to produce these layers by having successfully manufactured a minimum of ten million square feet of similar liner materials for hydraulic lining installations. The manufacturer must be listed by the National Sanitation Foundation Standard 54 as meeting all the requirements for manufacturing geotextiles and HDPE.

To qualify as an approved material lining manufacturer, the manufacturer shall submit lining material samples and minimum specifications to the CM for approval 60 days prior to the bid closing date. The specification sheet shall give full details of minimum physical properties and test methods used, site seaming methods, and a certificate confirming compliance of the material with the minimum specifications. A list of similar projects completed in which the manufactured material has been successfully used shall be submitted to the CM.

D.1.2.2 Lining Material

The new membrane liner shall comprise geosynthetic, geocomposite, and HDPE material manufactured of new, first-quality products designed specifically for the purpose of liquid containment in hydraulic structures.

The contractor shall, at the time of bidding, submit a certification from the manufacturer of the sheeting, stating that the sheeting meets physical property requirements for the intended application.

The liner materials shall be so produced as to be free of holes, blisters, undispersed raw materials or any sign of contamination by foreign matter. Any such defect shall be repaired by the contractor or the manufacturer using the extrusion fusion welding technique in accordance with the manufacturer's recommendations.

The lining materials shall be manufactured at a minimum seamless width of 22 ft. Labels on the roll shall identify the thickness, length, width, and manufacturer's mark number. There shall be no factory seams.

The liner materials shall meet the specification values according to the specifications provided by the manufacturer for the HDPE membrane layer.

D.1.2.3 Factory Quality Control

The contractor shall provide the project CM with documentation of the quality control program at the manufacturer's factory. The quality control program shall include the following elements:

1. Raw Materials. All compound ingredients of the HDPE materials shall be randomly sampled by the manufacturer on delivery to the HDPE manufacturing plant to ensure compliance with specifications. Tests to be carried out shall include Density ASTM D1505 and Melt Index ASTM D1238 Procedure A, Conditions E & P. The resin used to manufacture the HDPE must be Phillips TR400 or Chevron 9642.

2. Manufactured Roll Goods. Samples of the production run shall be taken and tested according to ASTM D638 to ensure that tensile strength at yield and break, and elongation at yield and break, meet the minimum specifications. A quality control certificate shall be issued with the material.

All welding materials shall be of a type recommended and supplied by the manufacturer and shall be delivered in the original sealed containers, each with an indelible label bearing the brand name, manufacturer's mark number, and complete directions as to proper storage. The resin used to manufacture the HDPE welding rod must be Phillips TR400 or Chevron 9642.

D.1.2.4 Instructions and Drawings Required after Contract Award

The manufacturer shall furnish complete written instructions for the storage, handling, installation, and seaming of the liner in compliance with this specification and the condition of the warranty.

The material supplier shall furnish complete written instructions for the repair of materials.

The manufacturer or a designated representative shall furnish panel layouts as required for the liner installation. The CM shall provide/the contractor with the final cap configuration, attachment details, and survey information needed.

D.1.2.5 Delivery and Storage

The material supplier shall furnish the layers in the condition of the manufacturer's warranty and with written instructions for the storage, handling, installation, and seaming of the liner in compliance with the specifications provided in this appendix. The shipment will be accepted provided it meets the aforementioned specifications.

The physical delivery of the layer rolls or pallets shall be in closed containers or trailers. The liner shall be loaded and unloaded by lifting rather than by pushing and pulling.

Unless the liner materials are installed directly as they come off the shipping trailer, a safe storage area shall be provided. The liner materials shall be elevated off the ground. If the liner materials are stored onsite for longer than one month, they should be covered and/or enclosed for protection.

D.1.2.6 Installation

D.1.2.6.1 Contractor Approval. The installation of the HDPE must be performed by the manufacturer or the manufacturer's approved installer using the manufacturer's extrusion welding equipment and installation methods.

D.1.2.6.2 Area Subgrade Preparation. Surfaces to be lined shall be smooth and free of all rocks, stones, sticks, roots, sharp objects, or debris of any kind. The surface should provide a firm, unyielding foundation for the membrane with no sudden, sharp, or abrupt changes or break in grade. No standing water or excessive moisture shall be allowed. Before commencing work, the installation contractor shall certify in writing that the surface on which the membrane is to be installed is acceptable.

The geosynthetic drainage layer will be anchored by placing the edge into a 2-ft-deep trench excavated around the entire edge of the cap. The trench will then be backfilled to hold the layer in place. The backfilled trench will be recompacted to specifications provided for the low-permeability layer (Appendix D.1.2).

D.1.2.6.3 Field Seams. Prior to welding, individual panels of liner material shall be laid out and overlapped according to the manufacturer's specification of acceptable maximum and minimum overlap of panels. Extreme care shall be taken by the installer in the preparation of the areas to be welded. The area to be welded shall be cleaned and prepared according to the procedures laid down by the material manufacturer. All sheeting shall be welded together by integrating the extrudate bead with the lining material. The composition of the extrudate shall be identical to the lining material.

The welding equipment used shall be capable of continuously monitoring and controlling the temperatures in the zone of contact where the machine is actually fusing the lining material to ensure that changes in environmental conditions will not affect the integrity of the weld. Only welding systems that utilize the extrusion fusion process shall be used for bonding the lining materials.

No "fish mouths" shall be allowed within the seam area. Where fish mouths occur, the material shall be cut, overlapped, and an overlap extrusion weld shall be applied. All welds on completion of the work shall be tightly bonded. Any membrane area showing injury due to excessive cuffing, puncture, or distress from any cause shall be replaced or repaired with an additional piece of HDPE membrane.

D.1.2.6.4 Field Seam Testing. The installer shall employ onsite physical nondestructive testing on all welds to ensure watertight homogeneous seams.

A quality-control inspector provided by the membrane manufacturer or an approved installer shall inspect each seam. Any area showing a defect shall be marked and repaired in accordance with HDPE repair procedures.

Test weld 3 ft long from each welding machine shall be run each day prior to liner welding and under the same conditions as exist for the liner welding. The test weld shall be marked with date, ambient temperature, and welding machine number. Samples of weld 1/4 to 1/2 in. wide shall be cut from the test weld and tested in shear and peel. Seams should be stronger than the material. The weld sample shall be kept for subsequent testing on laboratory tensiometer equipment in accordance with the applicable ASTM standards. Random weld samples may be removed from the installed welded sheeting at a frequency to be agreed (e.g., 1 per 500 ft of weld).

The manufacturer's CQA inspector will provide the results of the seam tests to the project CM, who will inspect and approve the seam test results.

D.1.2.7 Warranty and Guarantee

The manufacturer/installer shall provide a written warranty.

D.1.3 Topsoil Layer and Vegetated Cover

As shown on Construction Drawing D-4, the topsoil layer will consist of a minimum 2-ft-thick layer of materials derived from the borrow areas. These borrow materials must be free of roots, debris, and clods and/or rocks larger than 4 in. in diameter. Approximately 7,000 yd^3 of uncompacted material will be required to construct the topsoil layer of the cap. The soil will be obtained from a borrow source located at Site 300, and will not contain detectable concentrations of explosives compounds, VOCs, or metal concentrations above the TCLP. The lowermost 20 in. of material shall be compacted to the following dry densities within the specific moisture content range:

Modified Proctor	Moisture Content Range (%)
90%	Optimum moisture content to optimum moisture content + 4%

The uppermost 4 in. of material shall be prepared to the finish lines and grades delineated on the construction drawings and these specifications. Approximately 600 yd^3 of topsoil suitable for growing the vegetative cover will be required for the cover. A probable source for this material will be the borrow source located in the 827 Complex area that was used to complete the closure of the 827 lagoons (Carpenter, 1989). Once the proper lines and grades are established, the uppermost 4 in. shall be scarified or disked for soil fertilization.

D.1.3.1 Fertilizers

The fertilizer materials shall comply with the following analysis:

- 16% nitrogen
- 20% phosphorus
- 0% potassium.

Fertilizing materials shall comply with the applicable requirements of the California State Agricultural Code. All fertilizing materials shall be packaged, first-grade, commercial quality products identified as to source, type of material, weight, and manufacturer's guaranteed analysis. The contractor shall furnish a Certificate of Compliance stating that the material meets the specifications.

D.1.3.2 Seed

Seed shall be fresh, clean, new crop seed, mechanically premixed to specified proportions as designated in Appendix D.1.4.4.

Seed shall be delivered to the site in original unopened containers bearing the dealer's analysis and germination percentage, and a valid California Nursery Stock certificate or release by a county agriculture commissioner. Any seed tagged "warning, hold for inspection" shall be inspected by the San Joaquin Agriculture Commissioner. The seed will not be used unless released by the commissioner after the inspection.

D.1.3.3 Fiber Mulch

Fiber mulch shall be produced from natural or recycled (pulp) fiber, such as wood chips or similar wood materials or from newsprint, chipboard, corrugated cardboard, or a combination of these processed materials, and shall be free of synthetic or plastic materials. Fiber shall conform to the following:

- Contain 7% or less ash as determined by the Technical Association of the Pulp and Paper industry (TAPPI) Standard T413
- Contain less than 250 parts per million boron
- Be otherwise nontoxic to plant or animal life.

Fiber shall be of such character that the fiber will disperse into a uniform slurry when mixed with water. Water content of the fiber before mixing into slurry shall not exceed 15% of the dry weight of the fiber. Commercially packaged fiber shall have the moisture content of the fiber marked on the package.

D.1.3.4 Method of Placement

The seed, fertilizer, fiber, and other materials shall be placed by applying a slurry mixture under pressure (hydroseeding). The materials shall be applied at the following rates:

- 50–50 blend of Zorro Annual Fescue and Panoche Red Brome at 24 lb/acre
- Fertilizer at 500 lb/acre
- Mulch (wood fiber) at 1,500 lb/acre.

The seed, fertilizer, fiber, and other materials in the slurry mixture shall be as specified. All materials shall be of such character that they will disperse into a uniform slurry when mixed with water. The mixture shall be such that an absorbent porous mat will form when emplaced.

All materials must be available for inspection prior to application. Weights and contents of containers shall be clearly identified. A green coloring additive shall be used in the slurry for visual inspection purposes.

Areas to be planted by this method shall be moistened to a depth of 6 in., but the surface shall not be wet at the time of application.

The slurry planted areas shall be kept moist during the germination period, but puddling shall be avoided. The slurry shall be applied during the recommended fall planting season, October 1 to November 15.

D.1.4 Portland Cement Concrete

Portland cement concrete for drainage structures shall have a 28-day compressive strength of not less than 2,500 lb per square in. (Construction Drawing D-6).

To avoid segregation, concrete shall be deposited as close to its final position as is practicable. The use of vibrators for extensive shifting of the mass of concrete will not be permitted. Concrete that has partially hardened, has been retempered, or is contaminated by foreign materials shall not be deposited in the structure.

Concrete shall be placed in horizontal layers insofar as practical. Placing shall start at the low point and proceed upgrade unless otherwise permitted by the CM. Concrete shall be placed in a continuous operation between construction joins and shall be terminated with square ends unless otherwise shown on the plans.

Concrete shall be thoroughly consolidated in a manner that will encase the reinforcement and inserts, fill the forms, and produce a surface of uniform texture free of rock pockets and excessive voids.

D.1.5 Steel Reinforcement for Concrete

All reinforcing steel for concrete shall be Grade 40 billet steel conforming to ASTM A-615.

Steel-bending processes shall conform to the requirements of the Manual of Standard Practice of the Concrete Reinforcing Steel Institute (CRSI).

Bending or straightening shall be accomplished so that the steel will not be damaged. Kinked bars shall not be used.

Bar reinforcement shall conform accurately to the dimensions and details indicated on the plans or otherwise prescribed. Before being placed in any concrete work, it shall be cleaned thoroughly of all rust, mill scale, mortar, oil, dirt, or coating of any character that would be likely to destroy, reduce, or impair its proper bonding with the concrete.

D.2 Compaction Methods

A construction sequencing plan is provided in section 1.5. The cap is composed of three fine-grained soil materials: the top soil, low-permeability clay, and foundation layers.

D.2.1 Fine-Grained Compaction

After clearing the site, the burn pits will be filled with borrow soil and proof-rolled in accordance with Appendix D.3.2. The CM or CQA inspectors will inspect the proof-rolled surface. In the event that any unstable areas are discovered in the temporary cover, a bridging lift shall be placed. The pits and the bridging lifts will be filled in the same manner. Soil will be placed in evenly distributed layers not exceeding 12 in. in uncompacted thickness. These materials will be composed of foundation materials and will be moisture-conditioned as specified in Appendix D.3.

A minimum of six equipment passes shall be made with the specified equipment as provided in Appendix D.3.

The CM will approve the prepared surface prior to placement of any of the cap layers. Once approved, cap construction can commence by placement of the layer's specified materials in approximately horizontal, evenly distributed lifts not exceeding 6 in. in uncompacted thickness.

Before compaction, sufficient water shall be evenly applied to each lift of loose material to provide proper moisture content for satisfactory compaction. As the water is applied, the materials shall be disc-harrowed or otherwise similarly worked. The moisture content at the time of compaction shall be subject to the approval of the CM and/or staff. In the event that any lift is too moist to achieve the specified compaction, the compaction operations shall be delayed until the material has dried sufficiently to achieve the required compaction.

After each lift has been spread, worked, and properly moistened, it shall be compacted by approved compaction equipment meeting the minimum requirements of Appendix D.3, "Construction Equipment."

The specific number of passes required by compaction equipment to reach the specified levels of compaction will be determined by the CM and staff during grading operations. Based upon the analysis of compaction equipment, as presented in Appendix D.3, 4 to 6 equipment passes will be required to compact fine-grained materials.

The top surface of each lift shall be sufficiently scarified after compaction to provide bond with the succeeding lift within each layer.

At the end of each construction day or in the event of a construction delay, the top surface of each layer shall have sufficient crown to provide adequate drainage for water. The final slope of the graded layers shall be finish-graded to the elevations shown on the construction drawings, resulting in a smooth surface to prevent the mixing of materials between layers.

D.2.2 Corrective Procedures for Failed Moisture Density Tests

If the fill materials fail to meet the required minimum level of compaction, additional compactive effort will be provided until the specified density is achieved. If the CQA inspectors determine that the materials are either too wet or too dry to reach the required level of compaction, based upon moisture content testing in accordance with ASTM D-2216 or ASTM D-3017, the fill material will be scarified and moisture-conditioned prior to recompaction and retesting. Density and moisture testings of recompacted fill will be performed until the specified level of compaction has been achieved.

D.3 Construction Equipment

The construction equipment proposed for the closure activities shall include, but not be limited to, the items and tasks listed below.

Item	Proposed use
Caterpillar CP553, compactor vibratory sheepsfoot	Compact foundation and topsoil layers.
Caterpillar D6 bulldozer	Spread soil for compaction. Excavate from borrow area.
Caterpillar 966D wheel loader	Move cover materials short distances. Load trucks.
Case 580E backhoe	Excavate ditches.
Rammax P1620 vibratory sheepsfoot compactor	Compact cover materials in areas of limited work space.
Wacker VPG160	Compact cover materials in areas of limited work space.
Water truck (with operable fine mister)	Moisture condition cover materials.
Bottom dump trucks	Move cover materials to the pit area.

If the chosen contractor proposes to use equipment of equivalent capabilities, this equipment shall be substituted only upon submission of the equipment specifications and with approval from the regulatory agencies and the independent professional engineer.

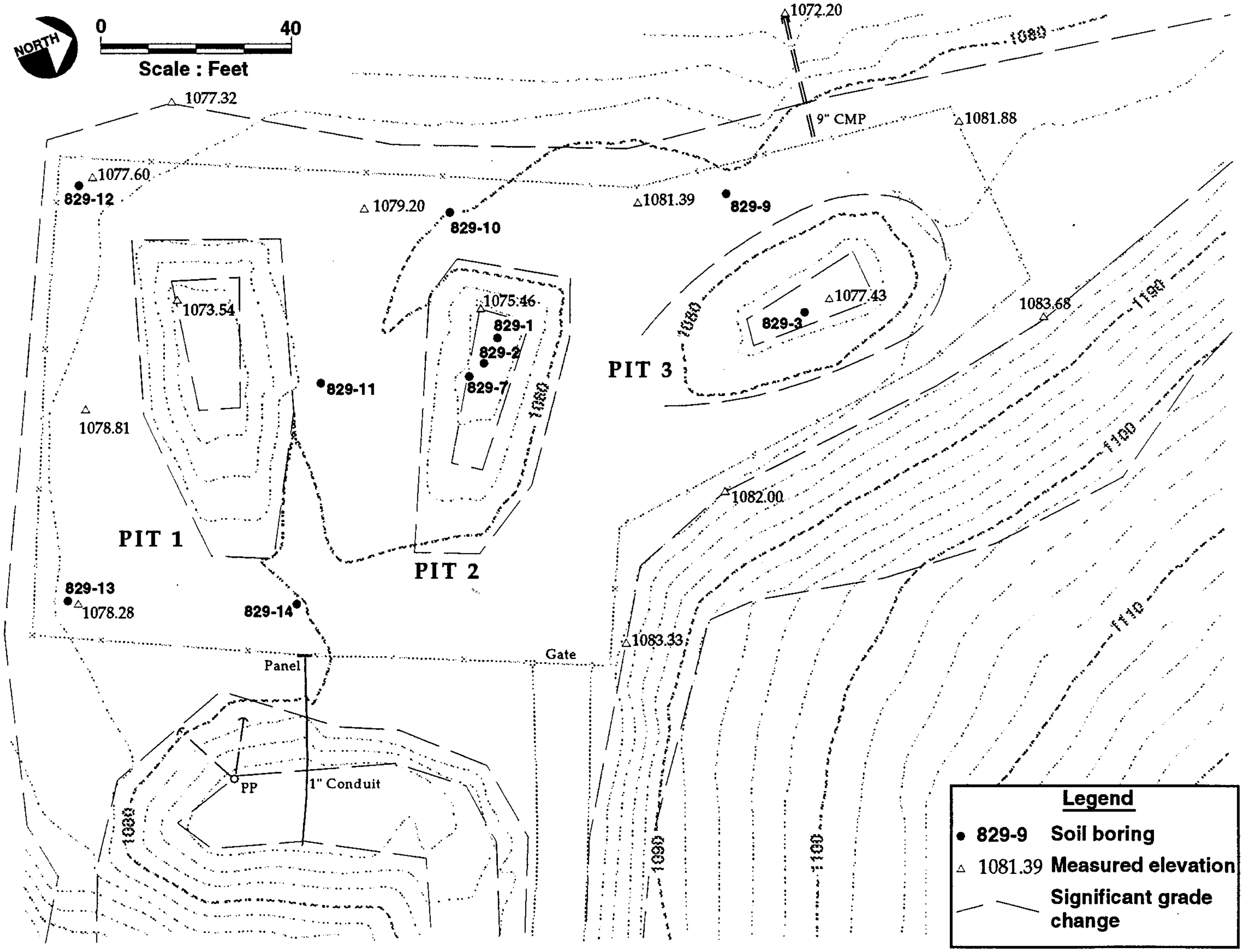
To facilitate compaction in areas where limited space is available, a Rammax P-1620 vibratory sheepsfoot roller (or equivalent) or a Wacker VPG160 (or equivalent) walk-behind plate tamper shall be used.

D.4 Temporary In-Progress Work Protection

The following contingency plan for inclement weather or long, unexpected interruptions (over 30 days) in the work schedule shall be implemented by the contractor to protect the in-place work:

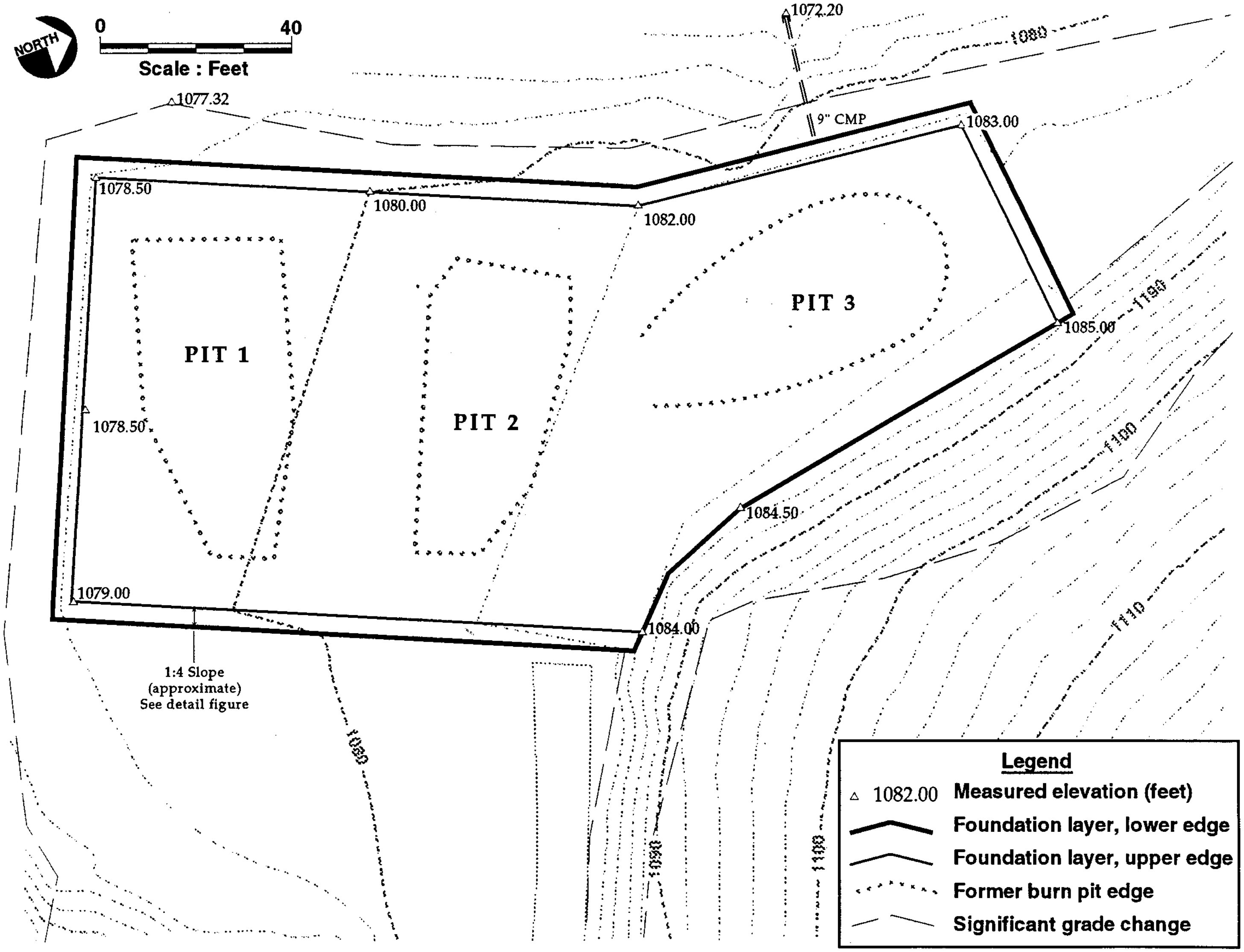
1. The affected area shall be graded in such a fashion that surface water will "sheet off" and not pond.
2. The affected area shall be covered in 6-mm polyethylene sheeting, which shall be secured by sandbags (minimum 30 lb).
3. The secured sheeting shall be inspected before and after each storm by the contractor to ensure continuous protection.

D.5 Construction Drawings



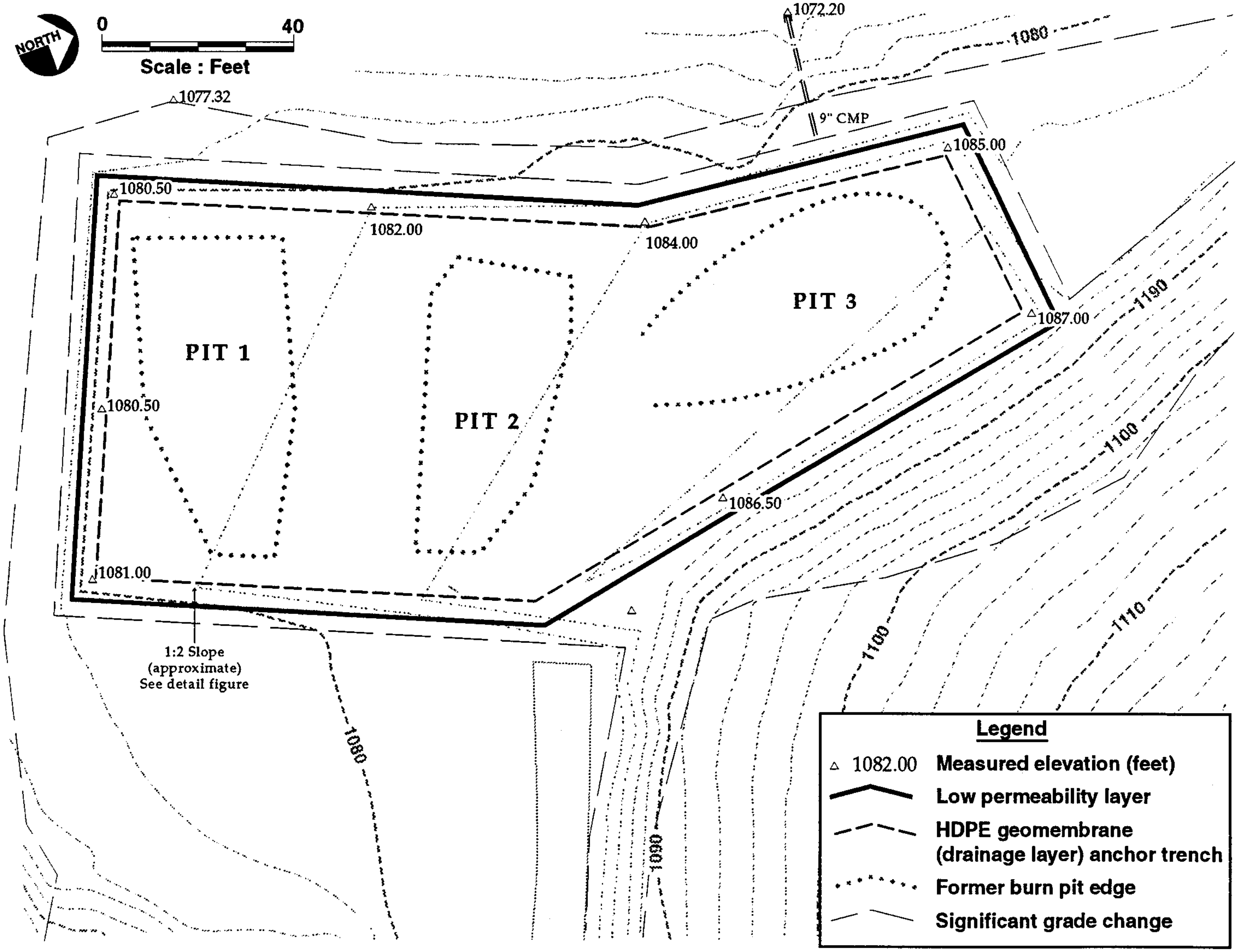
ERD-S3R-91-0294

Construction Drawing D-1. Prepared graded surface for existing fill material, closure of HE Open Burn Treatment Facility, Site 300, LLNL.



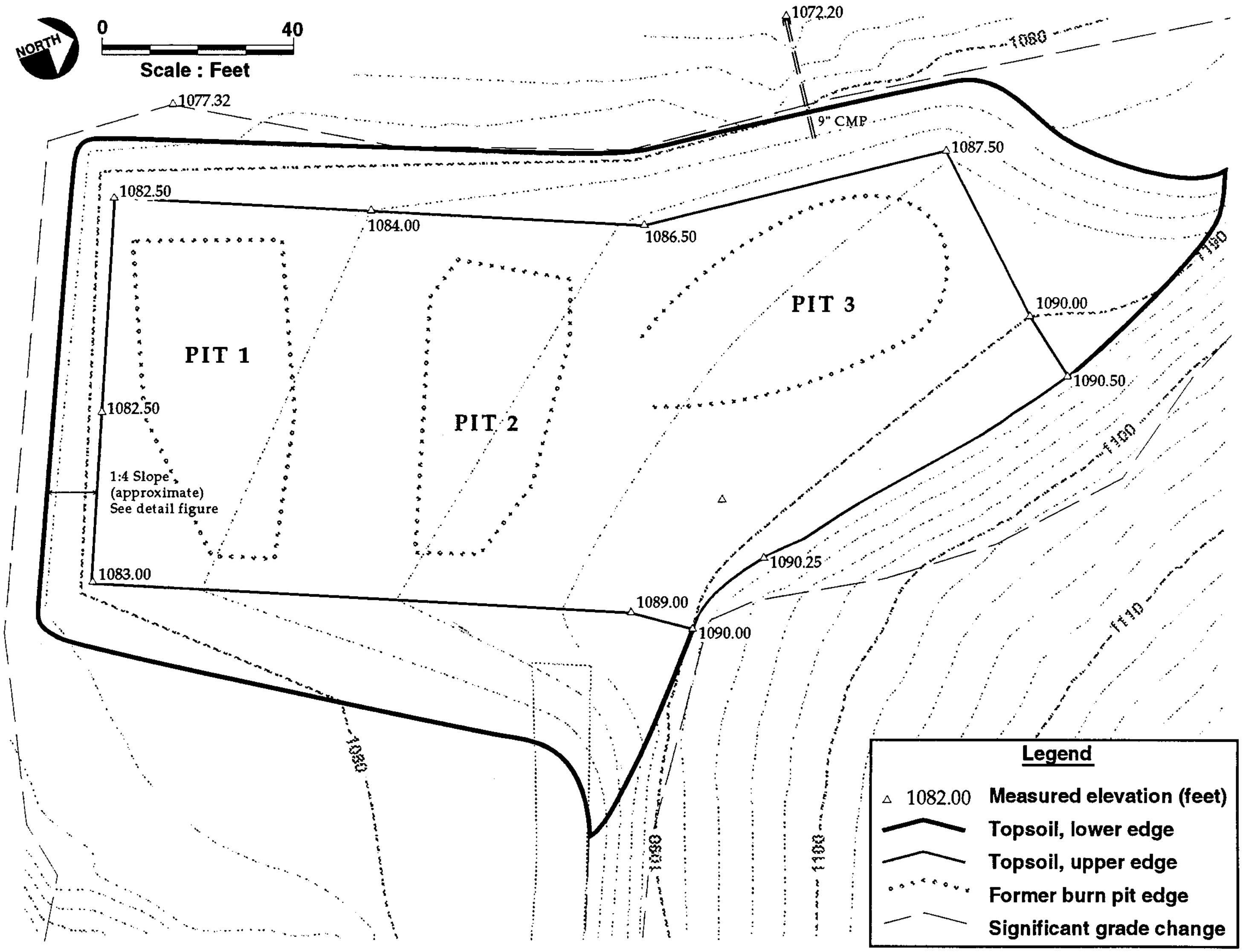
ERD-S3R-91-0293

Construction Drawing D-2. Foundation layer, closure of HE Open Burn Treatment Facility, Site 300, LLNL.



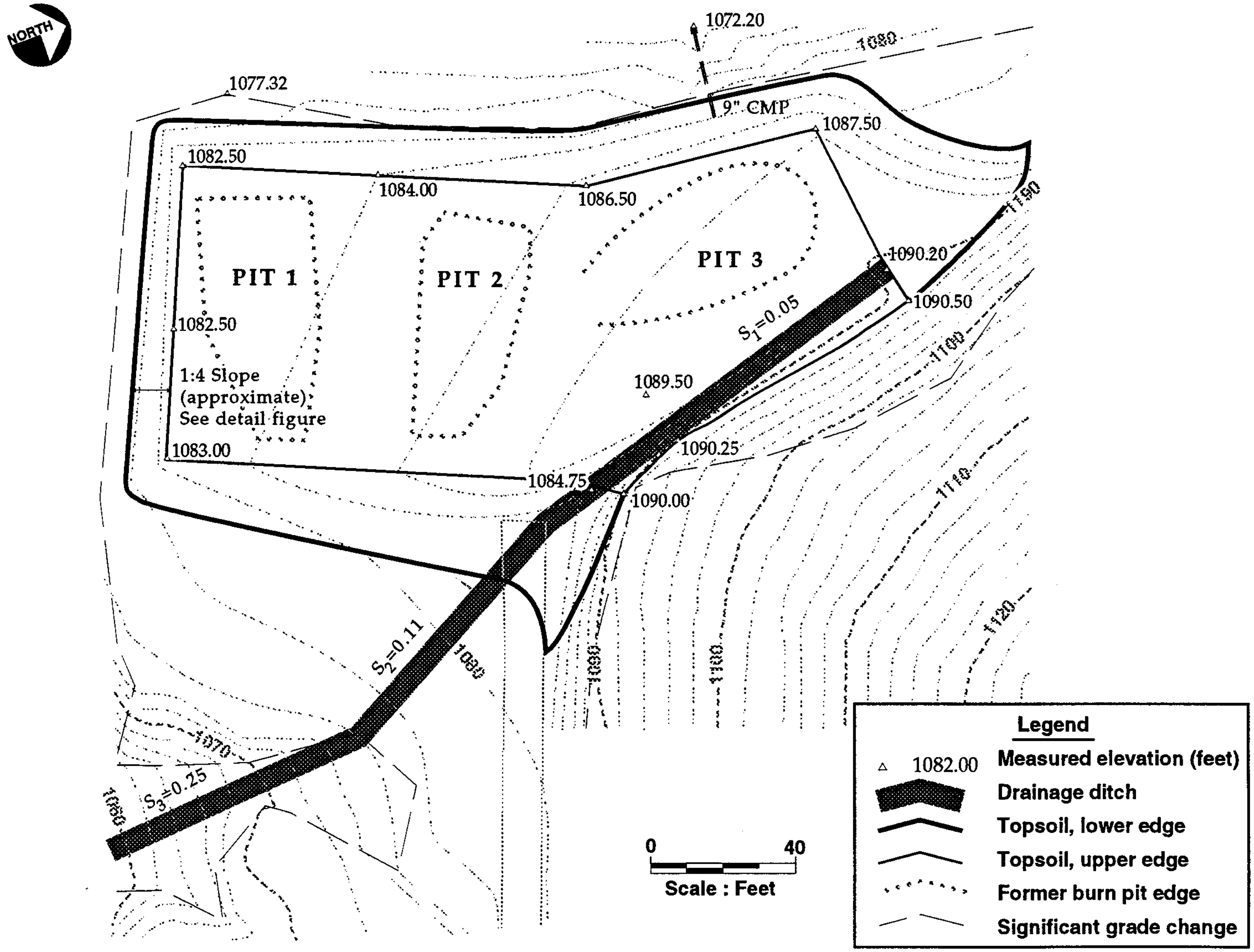
ORAD-97-0007

Construction Drawing D-3. Low-permeability layer, closure of HE Open Burn Treatment Facility, Site 300, LLNL.



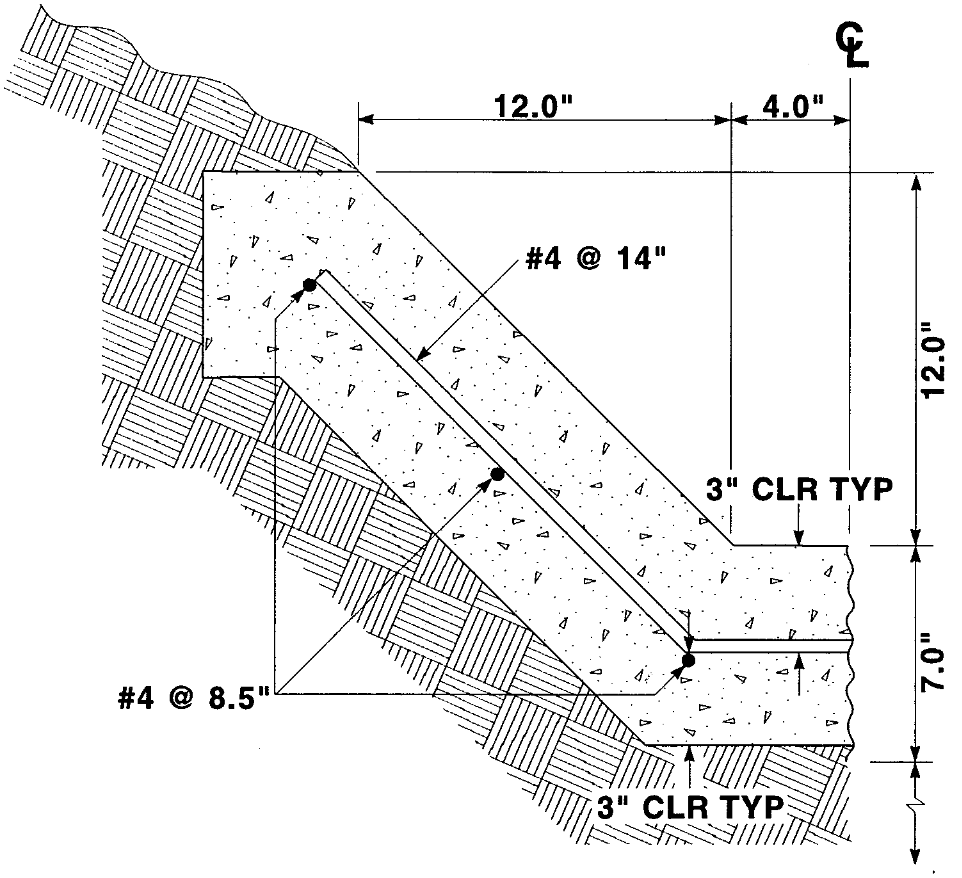
ERD-S3R-91-0291

Construction Drawing D-4. Topsoil and vegetative layer, closure of HE Open Burn Treatment Facility, Site 300, LLNL.



ERD-S3R-91-0290

Construction Drawing D-5. Final cover with drainage, closure of HE Open Burn Treatment Facility, Site 300, LLNL.



ERD-S3R-91-0289

Construction Drawing D-6. Concrete culvert, typical half section—HE Open Burn Treatment Facility closure, LLNL Site 300.

Appendix E

Appendix E.

Inspection Methods

Inspection Methods

Construction quality inspections will be performed to assure that the closure plan design criteria are adhered to during construction. The required construction quality inspections are outlined below according to the components of the final cover and their intended purposes. The inspections, the design criteria, and their frequency are summarized in Table E-1. All referenced testing procedures are listed in Table E-2. In addition, all materials will be prescreened in accordance with the prescreening plan presented in Appendix E.1.

Inspection Data Sheets will be used for field and laboratory inspection procedures and will ultimately become a part of the project documentation. Samples are presented in Appendix E-7.

E.1 Prescreening and Soil Classification Testing

A certificate provided by the supplier shall accompany materials imported to LLNL for use in the cap. The certificate shall include test results indicating that the stockpile from which these materials originated meets the technical specifications detailed in Appendix D. The supplier shall provide a certificate for each stockpile used.

Additional soil classification tests will be performed by the inspection staff to assess the consistency of incoming materials. Materials not in conformance with the technical specifications of this document shall be rejected and removed from the site at the contractor's expense.

The tests performed will consist of particle size analysis (ASTM Test D-422), Attenberg Limits (ASTM Test D-4318), if applicable, and soil classification (ASTM Test D-2487).

The tests will be performed on representative samples collected at random from truck loads. The number of tests to be taken will represent 25% of the frequency presented in Table E-1, or more frequently if the CM or inspection staff have reason to believe that the materials have substantially changed.

Because the designated borrow source for the foundation layer materials is located adjacent to the construction area, a prescreening program is not practical. However, testing should be performed prior to earth-moving in accordance with the CQA program as presented in Table E-1 and described below. Materials not in conformance with the technical specifications as presented in Appendix D shall not be used and will be removed from the construction site at the contractor's expense.

Table E-1. Summary table of CQA inspections.

Testing procedures	Design criteria	Frequency of testing
<u>Foundation Layer</u>		
1. Visual Observation Report	Surface free from large protrusions and organic matter.	Upon completion of finish grading of foundation layer.
2. In-place Density (ASTM D-2922)	95% relative density as per ASTM D-1557.	Minimum 1 test per 500 yd^3 of compacted material.
3. a. Moisture Content (ASTM D-2216)	From the optimum moisture content to the optimum moisture content + 4%.	Minimum 1 test per 500 yd^3 of compacted material.
b. Moisture Content (ASTM D-3017)		
4. Particle Size Analysis (ASTM D-422)	See technical specifications.	Minimum 1 test per 500 yd^3 of compacted material.
5. Moisture-Density Relations	N/A	N/A
6. Topographic Survey	N/A	Upon completion of finish grading of foundation layer.
<u>Low-Permeability Layer</u>		
1. Visual Observation Report of Delivered Geotextile and HDPE	Receipt of geotextile and HDPE in condition consistent with manufacturer's specifications.	Upon delivery of geotextile and HDPE to site.
2. Visual Observation Report of Geotextile and HDPE Installation	Placement according to technical specifications.	Prior to seam sealing.
3. Field Seam Test	See technical specifications.	Twice per day during seam sealing.
4. Visual Observation Report of Field Seams	See technical specifications.	Minimum 1 per 500 ft.
<u>HDPE Drainage Layer</u>		
1. Visual Observation Report of Delivered HDPE	Receipt of HDPE in condition consistent with manufacturer's specifications.	Upon delivery of HDPE to site.
2. Visual Observation Report of HDPE Installation	Placement according to technical specifications.	Prior to seam sealing.
3. HDPE Field Seam Test	See technical specifications.	Twice per day during seam sealing.
4. Visual Observation Report of Field Seams	See technical specifications.	Minimum 1 per 500 ft.

Continued on next page.

Table E-1. (Continued)

Testing procedures	Design criteria	Frequency of testing
<u>Final Cover and Vegetative Cover</u>		
1. In-place Density (ASTM D-2922)	90% or greater.	Minimum 1 test per 1,500 yd^3 of compacted material.
2. a. Moisture Content (ASTM D-2216) b. Moisture Content (ASTM D-3017)	From the optimum moisture content to the optimum moisture content +4%.	Minimum 1 test per 1,500 yd^3 of compacted material.
3. Particle Size Analysis (ASTM D-422)	See technical specifications.	Minimum 1 test per 1,500 yd^3 of compacted material.
4. Topographic Surveys and Field Staking	Layer thickness > 2 ft. Surface slope > 5%.	As needed.
5. Vegetation Type (Mfg.'s certification)	50–50 mixture Red Brome and Zorro Annual Fescue.	Prior to seeding.
6. Seeding Time	October 1 to November 15.	N/A

Table E-2. Test Procedures.

Test	Test designation
Particle-size Analysis of Soils	ASTM D-422
Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10 lb. (4.54 kg Rammer and 18 in. [457 mm] Drop)	ASTM D-1557
Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures	ASTM D-2216
Classification of Soils for Engineering Purposes	ASTM D-2487
Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)	ASTM D-2922
Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)	ASTM D-3017
Liquid Limit, Plastic Limit, and Plasticity Index of Soils	ASTM D-4318
Standard Practice for Thin-Walled Tube Sampling of Soils (Undisturbed Samples for Permeability Testing)	ASTM D-1587
Prescreening Plan and Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)	ASTM D-2488
Standard Practices for Preserving and Transporting Soil Samples	ASTM D-4220

E.2 Project Delays

In the event of a project delay, the exposed layer, except for lifts of the low-permeability layer, shall be proof-rolled with a fully loaded tandem-axle truck or earth-moving scraper. Any unstable areas shall be repaired under the direction of the CQA staff. The repair shall include removal of the unstable area and replacement with the appropriate layer materials in accordance with the compaction methods specified in Appendix D.2. Installation of the low-permeability layer shall not commence without assurance that the entire layer can be installed without delay. In the event of an unforeseen delay, the exposed lifts should not be proof-rolled.

E.3 Foundation Layer

The foundation layer will provide a uniform base for the overlying material layers composing the final cover system. In accordance with the closure plan, the foundation layer materials will be moisture-conditioned, compacted, and then finish-graded to remove any large surface protrusions from the project site.

E.3.1 Density/Moisture Testing

During grading operations, CQA inspectors will provide density and moisture content testing of the compacted fill in accordance with the test procedures outlined under ASTM D-2922 and ASTM D-3017 (or ASTM D-2216). A minimum of one density and moisture test will be performed for every 500 yd^3 of compacted material. Materials will be compacted to the relative dry densities outlined in the technical specifications, Appendix D, as determined by ASTM test D-1557. If the fill materials fail to meet the level of relative compaction, additional compactive effort will be provided until the specified density is achieved. If the CQA inspectors determine that the materials are either too wet or too dry to reach the relative compaction, based upon moisture testing in accordance with ASTM D-2216, the fill material will be aerated or moisture-conditioned in place prior to recompaction and retesting. Density and moisture testing of recompacted fill will be performed until the specified level of relative compaction is achieved.

E.3.2 Visual Inspections and Proof-rolling

Prior to construction and upon completion of the foundation layer, the CM and the CQA inspectors will provide the regulatory agencies with a visual observation report noting any anomalies (i.e., cracks, roots, etc.) or irregularities that would contribute to heterogeneity of the existing temporary cover and the foundation layer.

Prior to construction of the foundation layer, the existing fill will be proof-rolled with a fully loaded tandem-axle truck or earth-moving scraper. Any unstable areas shall be repaired under the direction of the CQA staff. The unstable area shall be "bridged" with a 12-in. lift of foundation layer materials. The bridging lift shall be compacted as specified in Appendix D. A summary of the proof-rolling operations and results shall be included within the visual observation report submitted to the regulatory agencies.

E.3.3 Topographic Survey

When final grading of each layer is completed, a topographic survey will be performed to provide a comparative base to determine the thickness of subsequent material layers comprising the closure cap. This survey will be performed in accordance with the guidelines given in section 1.5.8.5, "Topographic Surveys."

E.4 Low-Permeability Layer

A 2-part, low-permeability layer will be provided over the pit closure areas to minimize the infiltration and percolation of surface and storm drainage into the original fill material of the HE Open Burn Treatment Facility. The hydraulic conductivity design criteria for the low-permeability layer, as proposed in the closure plan, would be 1×10^{-7} cm/s or less.

E.5 Geosynthetic Clay, HDPE Geomembrane, and Geocomposite Drainage Layer

E.5.1 Delivery

The CM will be present to accept delivery of the layers to the construction site. The material supplier shall furnish the layers in the condition of the manufacturer's warranty and with written instructions for the storage, handling, installation, and seaming of the liner in compliance with the specifications provided in Appendix D. The shipment will be accepted by the CM, provided the layers meet the specifications provided in Appendix D and the manufacturer's warranty.

E.5.2 Installation

The CM shall conduct a visual inspection of the prepared surface prior to installation of the layers. The area subgrade shall be prepared in accordance with the specifications described in Appendix D. The CM shall confer with the installation contractor regarding the acceptability of the surface for layer installation. The installation contractor shall certify in writing that the surface on which the membrane is to be placed is acceptable before commencing work.

E.5.3 Field Seam Testing/Quality Control

The installer shall employ onsite physical nondestructive testing on all welds to ensure watertight homogeneous seams.

A quality-control inspector provided by the membrane manufacturer or an approved installer shall inspect each seam. Any area showing a defect shall be marked and repaired in accordance with geotextile and HDPE repair procedures.

Test weld 3 ft long from each welding machine shall be run each day prior to liner welding and under the same conditions as exist for the liner welding. The test weld shall be marked with date, ambient temperature, and welding machine number. Samples of weld 1/4 to 1/2 in. wide shall be cut from the test weld and tested in shear and peel. Seams should be stronger than the material. The weld sample shall be kept for subsequent testing on laboratory tensiometer equipment in accordance with the applicable ASTM standards. Random weld samples may be removed from the installed welded sheeting at a frequency to be agreed (e.g., 1 per 500 ft of weld).

The manufacturer's CQA inspector will provide the results of the seam tests to the project CM, who will inspect and approve the seam test results.

E.6 Topsoil Layer and Vegetative Cover

The topsoil layer and vegetative cover will protect the underlying layers from water and wind erosion. The 2-ft-thick topsoil layer will be compacted as specified in the technical specifications and will be graded to facilitate surface drainage. The CQA inspections will include monitoring the constructed thickness and surface slope of the topsoil layer, providing density testing for relative compaction, and obtaining certification of the vegetation seed and fertilizer mixes.

During grading operations, the CQA inspectors will conduct density, moisture content, and particle size testing of the compacted fill in accordance with the test procedures outlined under ASTM D-2922, ASTM D-3017 (or ASTM D-2216), and ASTM D-422. A minimum of one test panel will be performed for every 1,500 yd^3 of compacted materials. Materials will be compacted to the relative dry densities outlined in the technical specifications, Appendix D, as determined by ASTM D-1557. If the fill materials fail to meet the specified level of relative compaction, additional compactive effort will be provided until the specified density is achieved. If the CQA inspectors determine that the materials are either too wet or too dry to reach the relative compaction, based upon moisture content testing in accordance with ASTM D-2216 or ASTM D-3017, the fill material will be scarified and moisture-conditioned prior to the recompaction and retesting. Density and moisture testing of recompacted fill will be performed until the specified level of relative compaction has been achieved.

Field survey staking will be provided during grading operations to monitor the constructed thickness of the topsoil layer and to assure that the minimum 2 ft of material is provided. Upon completion of grading operations, a final topographic survey of the graded area will be provided in accordance with the procedures outlined under "Topographic Surveys" in section 1.5.8.5. In accordance with the closure plan, the final graded topography of the topsoil layer will be established according to that delineated on the construction drawings to provide for positive surface drainage of the final cover system.

Manufacturer's certifications of the seed and fertilizer mixes used in the vegetative cover will be required prior to hydroseeding the graded areas.

E.7 Inspection Data Sheets

The following data inspection sheets will be used by CMs and CQA inspectors during HE Open Burn Treatment Facility closure. The sample data sheets were prepared by Rogers/Pacific Professional Engineering Consultants.

- Construction Daily Summary Report
- Problem Identification and Corrective Measures Report
- Photographic Data Sheet
- Particle-size Analysis (ASTM D-422)
- Moisture/Density Relationship (ASTM D-1557)
- Moisture Content Test (ASTM D-2216)
- Unified Soil Classification System (ASTM D-2487)
- Field Density and Moisture Testing (ASTM D-2922 and ASTM D-3017)
- Attenberg Limits (Plasticity Index) (ASTM D-4318)
- Block Sampling Preserving/Transporting (ASTM D-4220)

Sheet No.________ of ________________

CQA Officer__________________________

RCE/CEG#__________________________

Signature__________________________

LLNL SITE 300

Construction Daily Summary Report

DATE:________________________________

LOCATION: B-829 HE Open Burn Treatment Facility

WEATHER:________________________________

EQUIPMENT IN USE:________________________________

CONTRACTOR'S WORK FORCE ON SITE:________________________

MATERIALS RECEIVED:________________________________

WORK DESCRIPTION:________________________________

INSPECTIONS PERFORMED (Inspection Sheet Numbers):________________

PROBLEMS AND CORRECTIVE ACTION TAKEN (if any):________________

PHOTOGRAPH SHEET NO(S):________________________________

Sheet No. ________ of ______________
CQA Officer________________________
RCE/CEG#________________________
Signature__________________________

LLNL SITE 300
Problem Identification and Corrective Measures Report

DATE:_________________________________
LOCATION: B-829 HE Open Burn Treatment Facility

DAILY CONSTRUCTION SUMMARY REPORT NUMBER:______________________
____

PHOTOGRAPH SHEET NUMBER(S):_______________________________________
____

PROBLEMS IDENTIFIED:____
(With Inspection Sheet No.):____
____
____
____

CORRECTIVE ACTIONS TAKEN:____
(With Inspection Sheet No.):____
____
____

Photograph Sheet No.

LLNL SITE 300

Photographic Data Sheet

INSPECTION SHEET NO.:
DATE:
LOCATION:

DESCRIPTION:

PURPOSE OF PHOTOGRAPH:

PHOTOGRAPHER:

SIGNATURE:

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PARTICLE SIZE ANALYSIS

ASTM D422-63

PROJECT NO. ____________ PROJECT ____________ SAMPLE ____________

DATE SAMPLED ____________ BY ____________

DATE TESTED ____________ BY ____________

SIEVE ANALYSIS

Sieve	Wt. Ret.	% Ret.	% Pass		SPECS
3					
2					
1-1/2					
1					
3/4					
1/2					
3/8					
1/4.3					
4					
TOTAL RET. #4		WBW(W) ____ WBW(D) ____			
PASS W 4 D.		WAW ____ ELUT. ____			
TOTAL					
8					
10					
16					
20					
30					
40					
50					
100					
200					
-200					
TOTAL					

D_{10} ____________

D_{30} ____________

D_{60} ____________

$$Cu = \frac{D_{60}}{D_{10}} = \_\_\_\_\_ = \_\_\_\_\_$$

$$Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \_\_\_\_\_ = \_\_\_\_\_$$

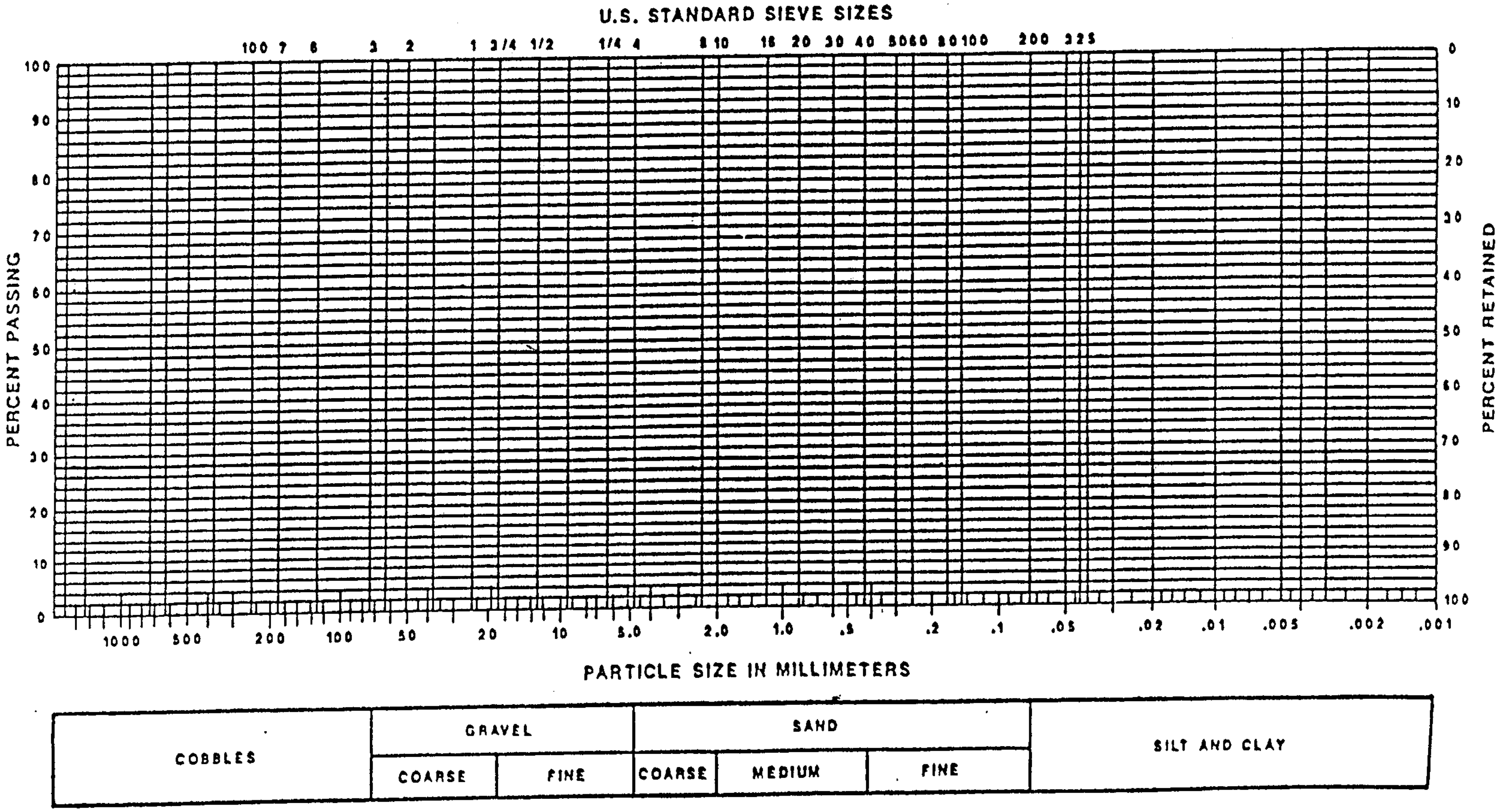
REMARKS:

Form 117

UNIFIED SOIL CLASSIFICATION SYSTEM

(ASTM D 422-72)

Curve	Sample	Depth	N.M.	L.L.	P.I.	% Grav	% Sand	% Silt &	% Clay	Key	Soil Classification



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P E-12 NO.

DATE -

Figure

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ASTM D1557-78
SOIL COMPACTION TEST

Job No. ____________________ Project ____________________

Location of Project ____________________ Sample No. ____________________

Description of Soil ____________________

Test Performed by ____________________ Date of Test ____________________

Mold Dimensions: Diam. __________ Ht. __________ Vol. __________

Weight of Hammer __________ No.of Layers _____ Blows/Layer __________

Water Content

Sample No.					
Can No.					
Wt. of Can + Wet Soil (1)					
Wt. of Can + Dry Soil (2)					
Wt. of Water (1)-(2) = (3)					
Wt. of Can (4)					
Wt. of Dry Soil (2)-(4) = (5)					
Water Content, % (3)/(5)					

Density

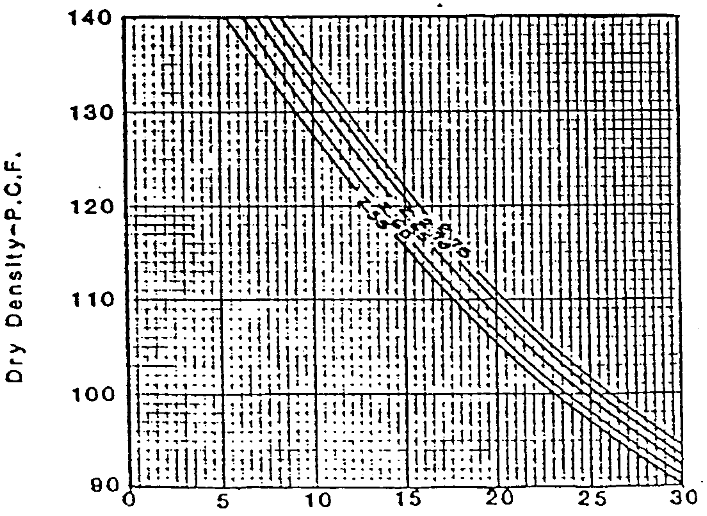
Water Content, %					
Wt. of Soil + Mold, g					
Wt. of Mold, g					
Wt. of Soil in Mold, g					
Wt. of Soil in Mold, lbs.					
Wet Density,pcf					
Dry Density, pcf					

Maximum Dry Density ____________________

Optimum Moisture ____________________

Soil Type ____________________

Curve Number ____________________



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MOISTURE CONTENT TEST

ASTM D2216-80

Project ______________________________ Job No. ______________________

Date Sampled ______________________________ Date Tested ______________________

by ______________________________ by ______________________

Placed in Oven: Date_______ Time__________ Oven Used: 110^{0}_______ MW__________

Removed and weighed: Date_______ Time__________

Field Sample Number									
Tray Number									
1. Wet wt. of soil + tare									
2. Dry wt. of soil + tare									
3. Wt. of water (1 - 2)									
4. Wt. of tare									
5. Wt. dry soil									
6. Moisture content (3)/(5) %									

Field Sample Number									
Tray Number									
1. Wet wt. of soil + tare									
2. Dry wt. of soil + tare									
3. Wt. of water (1 - 2)									
4. Wt. of tare									
5. Wt. dry soil									
6. Moisture content (3)/(5) %									

Field Sample Number									
Tray Number									
1. Wet wt. of soil + tare									
2. Dry wt. of soil + tare									
3. Wt. of water (1 - 2)									
4. Wt. of tare									
5. Wt. dry soil									
6. Moisture content (3)/(5) %									

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UNIFIED SOIL CLASSIFICATION SYSTEM

ASTM D-2487-85

PROJECT NAME ______________________ DATE ______________

PROJECT NO. ______________________ SAMPLE NO. ______________

PARTICLE SIZE ANALYSIS TEST SHEET NO. ______________________

ATTERBERG LIMITS TEST SHEET NO. ______________________

CLASSIFICATION DESCRIPTION ______________________

____

____

____

CLASSIFICATION PERFORMED BY ______________________

PRIMARY DIVISIONS			GROUP SYMBOL	SECONDARY DIVISIONS
COARSE GRAINED SOILS MORE THAN HALF OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVELS MORE THAN HALF OF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LESS THAN 5% FINES)	GW	Well graded gravels, gravel-sand mixtures, little or no fines.
			GP	Poorly graded gravels or gravel-sand mixtures, little or no fines.
		GRAVEL WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines.
	SANDS MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LESS THAN 5% FINES)	SW	Well graded sands, gravelly sands, little or no fines.
			SP	Poorly graded sands or gravelly sands, little or no fines.
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures, non-plastic fines.
			SC	Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS MORE THAN HALF OF MATERIAL IS SMALLER THAN NO 200 SIEVE SIZE	SILTS AND CLAYS LIQUID LIMIT IS LESS THAN 50%		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
	SILTS AND CLAYS LIQUID LIMIT IS GREATER THAN 50%		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils.

DEFINITION OF TERMS

U.S. STANDARD SERIES SIEVE — CLEAR SQUARE SIEVE OPENINGS

200 — 40 — 10 — 4 — 3/4" — 3" — 12"

SILTS AND CLAYS	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

SUMMARY OF FIELD DENSITY/MOISTURE TESTING

ASTM D2922-81
ASTM D3017-78

J.N. ____________________

PROJECT ____________________

TECHNICIAN ____________________

NO.	LOCATION	DATE	DESIGN FILL DEPTH FEET	FILL DEPTH FEET	TEST DEPTH FEET	TEST ELEV.	FIELD DENS. PCF	MOIS. CONT. %

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ATTERBERG LIMITS (Plasticity Index)
ASTM D4318-84

PROJECT ____________________ JOB NO. ____________

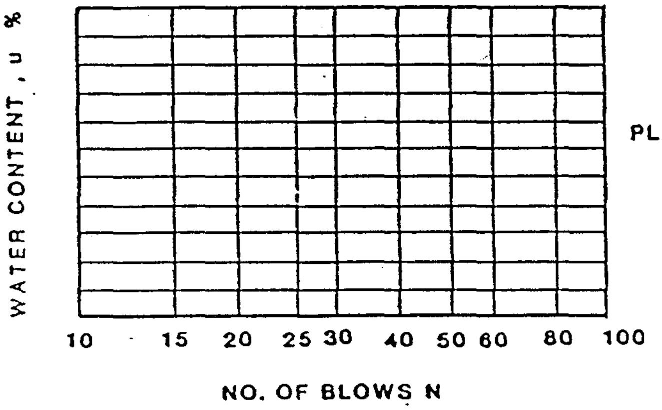
LOCATION OF PROJECT ____________________ BORING NO. ________ SAMPLE NO. ________

DESCRIPTION OF SOIL ____

DEPTH OF SAMPLE ____________ TESTED BY ____________________ DATE ____________

LIQUID LIMIT DETERMINATION

CAN NO.						
WT. OF WET SOIL + CAN						
WT. OF DRY SOIL + CAN						
WT. OF CAN						
WT. OF DRY SOIL						
WT. OF MOISTURE						
WATER CONTENT %						
NO. OF BLOWS N						



LIQUID LIMIT =

PLASTIC LIMIT =

PLASTICITY INDEX Ip =

PLASTIC LIMIT DETERMINATION

CAN NO.				
WT. OF WET SOIL + CAN				
WT. OF DRY SOIL + CAN				
WT. OF CAN				
WT. OF DRY SOIL				
WT. OF MOISTURE				
WATER CONTENT %				

PLACED IN OVEN: DATE ____________ TIME ________

REMOVED FROM OVEN: DATE ____________ TIME ________

Page __ of __

DATA FORM FOR SDRI TEST

Project: ____________________
Inner ring info: ____________________
Outer ring info: ____________________
Liner thickness (cm) : ____________________

$$I = Q/(At)$$

I = infiltration (cm/sec)
Q = quantity of flow (ml)
t = interval of time (sec)
A = area of inner ring (cm 2) __________

Date	Initial time (sec)	Final Time (sec)	t Interval of Time (sec)	Initial Wt. of Bag (grams)	Final Wt. of Bag (grams)	Q Quan. of Flow (ml)	I Infiltra-tion (cm/sec)	Temp. (C)	Water Depth (in)

NOTES:

DATE	TIME	TENSIOMETER READING - CENTIBARS											
		DEPTH - 6"				DEPTH - 12"				DEPTH - 18"			
		GROUP 1	GROUP 2	GROUP 3	AVG.	GROUP 1	GROUP 2	GROUP 3	AVG.	GROUP 1	GROUP 2	GROUP 3	AVG.

PROJECT: ____________________

TENSIOMETER TYPE: ____________________

NOTES:

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WORK SHEET – PERMEABILITY

Job:		Job No.	Date
Hole No.	Depth	Sample Diameter	Unit No.

Description of Sample and Remarks: @ psi (psf)

Backpressure Saturated

Specific Gravity, C	
+ No. 4	- No. 4

WEIGHTS AND WATER CONTENTS

Formula: Water Content, $w = \frac{W_w}{W_s} \times 100$

			Before Test		After Test						
					Wedge		Solids		Total		
	Tare No.										
Weights in lbs. grams	Tare + Wet Soil										
	Tare + Dry Soil										
	Water	W_w									
	Tare										
	Wet Soil										
	Dry Soil	W_s				+		=		= W_s	
	Water Content %	w									

DIMENSIONS

	Areas in sq. cm.									
	Top	Middle	Bottom	Avg.	Membrane Thick.	Membrane Corr.	A, Net Area	Height	in.	cm.
Before Test								h_o =		
After Evacuation								h_{c_1} =		
After Saturation								h_{c_2} =		
After Consolidation	▨	▨	▨	▨	▨	▨		▨	▨	

k=

Dimensions After Consolidation

V_o =

A_{c_1} =

A_{c_2} =

GENERAL DATA

Chamber Pressure,	psi	0				
Back Pressure	psi	0				
Date		/ /		/ /		/ /
Hour						
Strain Dial Reading	in.					
Interior Burette,	cc.					
Exterior Burette,	cc.					
Volume of Specimen, $V = A \times H$	cc.					
Volume of Solids, $V_s = W_s \div C$	cc.					
Volume of Voids, $V_v = V - V_s$	cc.					
Void Ratio, $e = V_v \div V_s$						
Dry Density, $\gamma_d = 62.4 \; W_s \div V$, lbs/ft^3						
Saturation, $S = V_w \div V_v \times 100$,	%					

Tested by:

Computed by:

Checked by:

ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

SATURATION & CONSOLIDATION PHASE - PERMEABILITY

PROJECT ____________________

____________ NO. ____________ DATE ____________

BOR DEPTH

SATURATION DATA

UNIT NO.

TIME DATE	σCHAMBER PRESS. (psi)	σBACK PRESS. (psi)	EXTERNAL BURETTE (cc)	SATURATION BURETTE (cc)	PORE PRESSURE (psi)	Δ	B

Δ Δ NET

CONSOLIDATION DATA

ELAPSED TIME MIN.	INTERIOR VOL. BURETTE (CC)	
		Δ
0		0
.1		
.25		
.5		
1		
2		
4		
8		
16		
30		
60		
120		
240		
480		
1440		

Date:
Time:
σ_{CH} =
σ_{BP} =
σ =
(CONSOL.)

Tested by ____________ Computed by: ____________ Checked by: ____________

PERMEABLITY TEST DATA

ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

UNIT NO.______ BORING______ DEPTH______ CONSOL. PRESS.______ psi

PROJECT______________ NO.______ DATE______ PRESS. HEAD______ psi

Type of Test FALLING HEAD

Chamber Press. psi

Back Press. psi

$k = \frac{aL}{At} \log_e h_o/h_f$ cm./sec.

where:

a = ______ cm^2, L = ______ in. = ______ cm.

A = ______ cm^2, t = ______ hrs. ______ min.

= ______ x10 sec.

h_o = ______ cc = ______ cm.

h_f = ______ cc = ______ cm.

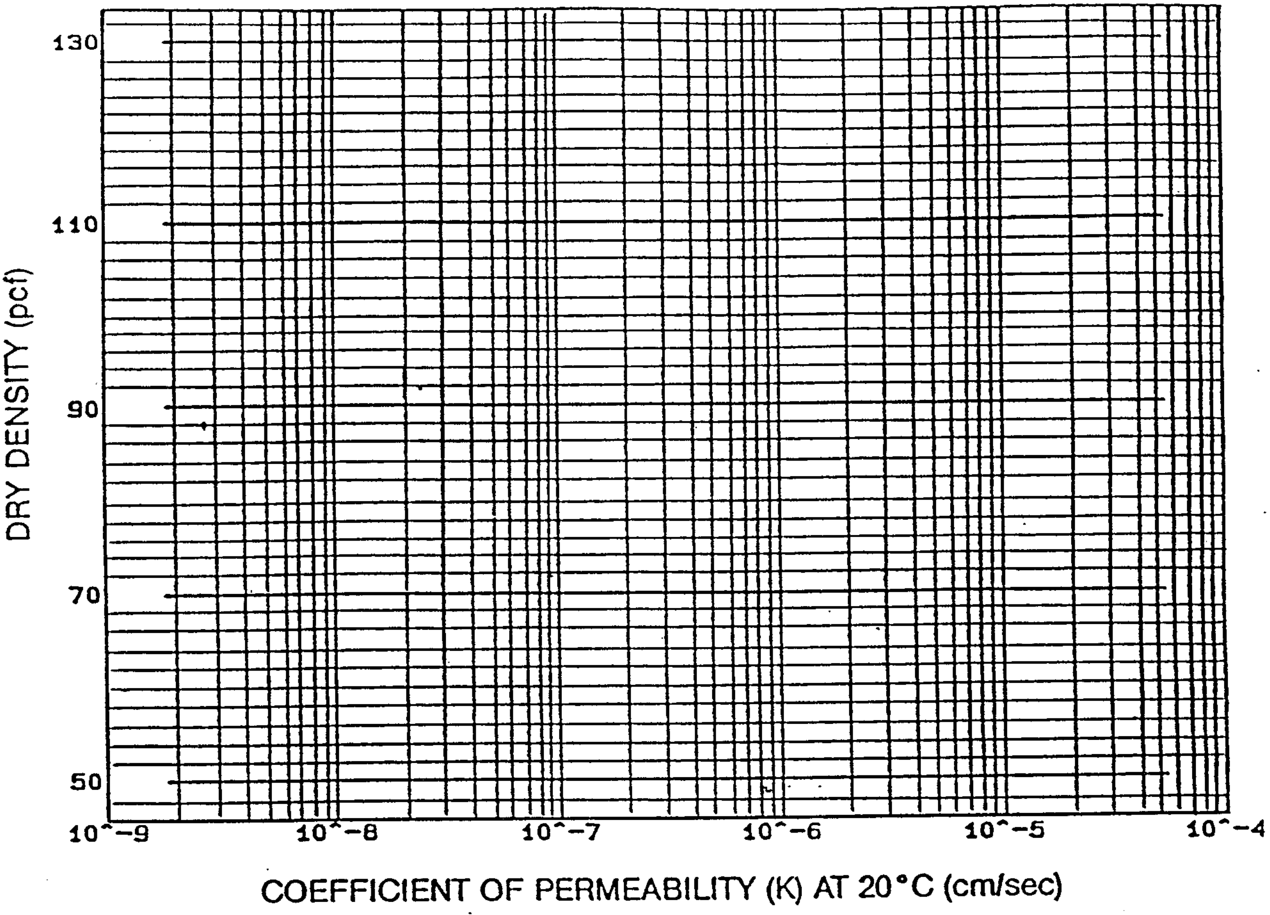
E-22

Burettes						
Ext. cc	Bott. Int. cc	Δ Int. cc	Sum Int. cc	Top Int. cc	Time	Date

Tested by:

Computed by:

Checked by:



PHYSICAL CONDITIONS		TEST NO		
		A ◻	B △	C
INITIAL	Diameter (in)			
	Height (in)			
	Water Content (%)			
	Dry Density (pcf)			
	Void Ratio			
	Saturation (%)			
FINAL	Consolidation Pressure (psf)			
	Water Content (%)			
	Dry Density (pcf)			
	Void Ratio			
	Saturation (%)			
Permeability At 20°C (cm/sec)				

Sample Source:

Classification:

TEST TYPE:

SATURATION METHOD:

ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

Permeability Test Report

PROJECT NO.	DATE	Figure

ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

396 Civic Drive   Pleasant Hill, California 94523   (415)682-7601

UNDISTURBED BLOCK SAMPLE (ASTM D4220)

Project Name ______________________________

Sample No. ______________________________

Date Sampled ______________________________

Orientation of Sample Maintained ______________________________

Description of Soil ______________________________

Sample Excavated By ______________________________

Sample Dimensions ______________________________

Location of Sample ______________________________

Permeability Test Sheet No. ______________________________

Date of Permeability Test ______________________________

Appendix F

Appendix F.

Engineering Analyses for Closure

Engineering Analyses for Closure

F.1 Static Settlement Analysis*

This section presents analytical methodology, design data, and results of a static settlement analysis. The purpose of this assessment is to evaluate the impact of settlement on the integrity of the final cover system. Computations include both elastic settlement of granular components and consolidation settlement of fine-grained components of the cover system.

F.1.1 Background Data and Assumptions

A cross section of the final cover system is presented in the attached calculation brief in Supplement F.I. The granular components design parameters were estimated using empirical correlations based on material type and a conservative estimate of the *in situ* relative density. The fine-grained cover components consist of the following, from top to bottom: vegetative layer, foundation layer, and the existing fill material. Because it is the top layer, it is assumed that the vegetative layer will experience no change in loading conditions and will not consolidate. The foundation layer and original fill material are constructed of the same local borrow material. For the purpose of this settlement analysis, it is assumed that the existing fill material and foundation layer are 15 ft thick combined. The foundation layer and existing fill material are considered equally compressible.

To estimate the worst-case scenario (worst degree of settlement), samples of the borrow materials for the HE Open Burn Treatment Facility were prepared at 80% of Modified Proctor Density. Terzaghi's one-dimensional consolidation tests were performed on the prepared samples. Results of the laboratory tests are presented in Table F-1. Details of the parameters and the theory used are included in the attached calculation brief.

Table F-1. Terzaghi's laboratory test results.

Material	Initial void ratio (e_0)	Preconsolidation stress (psf)	Compression index (Cc)	Recompression index (Cr)
Foundation/ existing fill	0.99	1,100	0.25	0.035

---

*See Supplement F.I. entitled "Static Settlement Analysis."

F.1.2 Results and Conclusions

The worst-case scenario was applied to the HE Open Burn Treatment Facility to estimate the maximum feasible static settlement. Because of the relatively small thickness of each layer, the granular components of the cover system were considered together for ease of analysis. Results of the analysis are as follows:

Layer	Method of estimating static settlement	Estimate of static settlement (in.)
Vegetative layer	N/A	0.00
Foundation layer and existing backfill	Consolidation	0.67
	Total estimated static settlement	1.01

F.2 Drainage Ditch Design*

F.2.1. Design Run-off Hydrology

The design flow rate (Q) for the channel design is based on estimated surface runoff flows calculated by the Rational Method. The three input parameters to the Rational Method are rainfall intensity, surface area, and a surface runoff coefficient.

The nearest rainfall data station, Livermore 5NE AC24 (Rainfall Depth-Durations-Frequency for California, Department of Water Resources, last updated August 1986), provided the probable maximum precipitation (PMP) rainfall event for design purposes. The shortest duration PMP documented was 0.89 in. in 5 minutes. The estimated time to concentration (t_c) is 2 minutes for the site. The t_c is the flow time from the uppermost point in the drainage area to the outlet channel above the HE Open Burn Treatment Facility. The minimum duration PMP provided is used as the design rainfall event. The 5-min PMP was standardized to an equivalent rainfall of 10.7 in./hr. The total drainage area of the hillside and Open Burn Treatment Facility is about 2.5 acres. The estimated drainage area includes the hillside area northeast of the pits and the closure cap. The Rational Method is most reliably applied to small watersheds, which are areas less than 100 acres. The runoff coefficient applied was 0.60, representing agricultural bare-packed, smooth soil with 0 to 30% slopes and greater-than-average runoff (Goldman *et al.*, 1972). Based on the above parameters, total runoff from the site is estimated at 16.3 f^3/s.

---

*See Supplement F.II. entitled “Drainage Ditch Design.”

F.2.2. Hydraulic Design

A concrete-lined channel is designed to intercept and transmit surface water runoff away from the Open Burn Facility cap. The culvert will be located above the Open Burn Facility cap at the base of the cut slope on the northeast side to collect primarily hillside runoff. Captured runoff will be diverted to a natural drainage about 200 ft from the HE Open Burn Treatment Facility and ultimately to the Corral Hollow Creek. Surface water runoff from the cap itself, approximately 0.8 acres, will run off the cap to the south and southeast down the steep hillside of exposed Neroly sandstone (Construction Drawing D-5 in Appendix D.5).

The drainage channel is designed to carry a maximum flow of 16.3 f^3/s. Manning's equation for open channel flow is used to design the channel. Design slopes for the culvert range from 5 to 25%. Segment 1 is 80 ft at 5% slope, Segment 2 is 147 ft at 11% slope, and Segment 3 is 40 ft at 25% slope. The minimum slope yields maximum flow depth, and the maximum slope yields the maximum flow velocity for the maximum expected flow. Therefore, the maximum depth of flow, 0.8 ft, will occur in Segment 1 and the maximum estimated velocity, 25 f/s, will occur in Segment 3.

The design channel for all three segments is a trapezoidal concrete-lined culvert with a 9-in. bottom width, 1:1 side slopes, and 12-in. lined depth. The depth of water at maximum design flow and minimum slope are estimated at less than 10 in. The maximum superelevation from channel bends would add less than one inch to the maximum depth of flow. Therefore, the 12-in. depth of the concrete-lined channel was chosen for all locations.

F.2.3. Channel Structural Lining

The concrete structural lining uses No. 4 reinforcing bars in both directions with 3-in. clearance top and bottom, providing a minimum thickness of 7 in. The reinforcement minimum spacing chosen, at least one No. 4 bar every 14 in., is based on shrinkage and temperature criteria in accordance with the American Concrete Institute Code 318-88 and Uniform Building Code (1988).

F.2.4. Channel Outlet Erosion Protection

The design flow rate from the concrete channel is estimated at 16.3 f^3/s. At a channel slope of 25%, the estimated discharge velocity is 25 f/s. To minimize the potential for downslope erosion at the channel outlet, a down slope cobble apron will be installed. The apron will be at least 3 ft each side and extend at least 10 ft down slope from the channel outlet.

F.3 Compaction Equipment Selection*

The objective is to select appropriate compactive equipment for constructing cover layers to specifications (Appendix D).

F.3.1 Foundation/Topsoil Layers

Compaction goals for the foundation layer and topsoil layer specified in Appendix D will result in compaction to approximately 95% of the Standard Proctor Maximum Density. Compaction with 4 to 6 passes using the sheepsfoot roller can be used to achieve these compaction specifications for clays. Given a PI less than 30%, the foot contact area shall be between 7 and 14 ft^2, and the foot contact pressure will be between 200 and 400 psi (NAVFAC DM 7.2).

F.4 Soil Erosion Protection

The objective is to estimate potential soil loss from closure cap and to evaluate whether loss meets acceptable closure criteria.

F.4.1 Method: USDA Universal Soil Loss Equation

To calculate the average annual soil loss, the USDA Universal Soil Loss Equation is used.

$$A = RK\,(LS)\,CP$$

Where

A = Average annual soil loss (tons/acre/time)
K = Rainfall and runoff erosivity index
L = Slope—length factor
S = Slope—steepness factor
C = Cover—management factor
P = Practice cover

From tables and figures in Whipple *et al.* (1983),

R = 25
K = 0.32 (silty clay loam)
(LS) = 0.63
C = 0.05 (permanent seeding 60–365 days)
P = 0.75 (prepared as pasture land, but not grazed)
A = $25 \times 0.32 \times 0.63 \times 0.05 \times 0.75 = 0.19$ t/acre/year

Annual soil loss is less than 2 t/acre/year and, therefore, meets acceptable criteria.

F.5 Fertilizer Selection

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
CALIFORNIA

For: Lissa Miner - Weiss Associates

Job Location: CORRALL HOLLOW, LIVERMORE

County Alameda RCD Alameda

Permit No.__________ Preped By A. Cerna Date 8/90

CONSTRUCTION REQUIREMENTS
For

Critical Area Planting-342
(Practice Code and Name of Practice)

IT SHALL BE THE RESPONSIBILITY OF THE OWNER TO OBTAIN ALL NECESSARY PERMITS AND/OR RIGHTS, AND TO COMPLY WITH ALL ORDINANCES AND LAWS PERTAINING TO THIS CONSTRUCTION.

Construction shall be in accordance with the following drawings, specifications and special requirements:

1. Drawings, Nos.______, ______, ______, ______, ______,

2. Construction Specifications 342 , _____, _____, _____, _____,

3. Special Requirements: Seedbed Preparation: Scarification of Slopes If seeding is to be late, then a tackifier should be used during application. In order for the tackifier or Hydromulch to be effective the application will need to be allowed to dry.

Seed: Hydroseeding - Zorro Annual Fescue 12 lbs./ac., Panoche Red Brome 12 lbs./ac.(optional - Barley 90 lbs./ac.)(Pure Live Seed).
Broadcast- same *Optional- include Rose Clover at 10 lbs./ac. (Must be innoculated)

Critical Area Planting (342) -
Seedbed preparation - same as above
Seed - as outlined above Rate - as outlined above
Fertilizer - 16-20-0 Rate - 500 lbs/ac
Mulch : Wood Fiber - 1500 lbs./ac.
Clean Straw- 4000 lbs./ac. (Wheat straw preferred)

4. Special Maintenance Requirements: Straw if used must be anchored to prevent displacement.

Seeding Dates: October 1, as per Alameda County requirements

NO CHANGES ARE TO BE MADE IN THE SPECIFICATIONS WITHOUT PRIOR APPROVAL OF THE SCS TECHNICIAN.

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
CALIFORNIA

ALTERNATIVE TWO

For: Lissa Miner - Weiss Associates

Job Location: CORRAL HOLLOW, LIVERMORE

County Alameda RCD Alameda

Permit No.________ Preped By A. Cerna Date 8/90

CONSTRUCTION REQUIREMENTS
For

Critical Area Planting-342
(Practice Code and Name of Practice)

IT SHALL BE THE RESPONSIBILITY OF THE OWNER TO OBTAIN ALL NECESSARY PERMITS AND/OR RIGHTS, AND TO COMPLY WITH ALL ORDINANCES AND LAWS PERTAINING TO THIS CONSTRUCTION.

Construction shall be in accordance with the following drawings, specifications and special requirements:

1. Drawings, Nos.______, ______, ______, ______, ______,

2. Construction Specifications 342 , ____, ____, ____, ____,

3. Special Requirements: Seedbed Preparation: Scarification of Slopes SEED AND FERTILIZER TO BE APPLIED WITH HYDROSEEDER FOLLOWED BY STRAW MULCH. TACKIFIER TO BE APPLIED WITH HYDROSEEDER FOLLOWING STRAW MULCH APPLICATION. AREAS SEEDED AND FERTILIZED TO BE MULCHED THE SAME DAY TO PREVENT EXCESSIVE LOSS TO WIND, ANIMALS OR RAINFALL.

Seed: Hydroseeding - Zorro Annual Fescue 12 lbs./ac., Panoche Red Brome 12 lbs./ac. (optional - Barley 90 lbs./ac.) (Pure Live Seed).

Broadcast- same *Optional- include Rose Clover at 10 lbs./ac. (Must be innoculated)

Critical Area Planting (342) -

Seedbed preparation - same as above .

Seed - as outlined above Rate - as outlined above .

Fertilizer - 16-20-0 Rate - 500 lbs/ac .

Mulch : Clean Straw- 4000 lbs./ac. (Wheat straw preferred) .

4. Special Maintenance Requirements:________ .

Seeding Dates: October 1, as per Alameda County requirements .

NO CHANGES ARE TO BE MADE IN THE SPECIFICATIONS WITHOUT PRIOR APPROVAL OF THE SCS TECHNICIAN.

The Plant Materials Center located in Lockeford, California is one of the 23 centers the Soil Conservation Service operates. Special emphasis is placed on finding suitable plants for erosion control on soils and sites where it is difficult to establish protective vegetative cover.

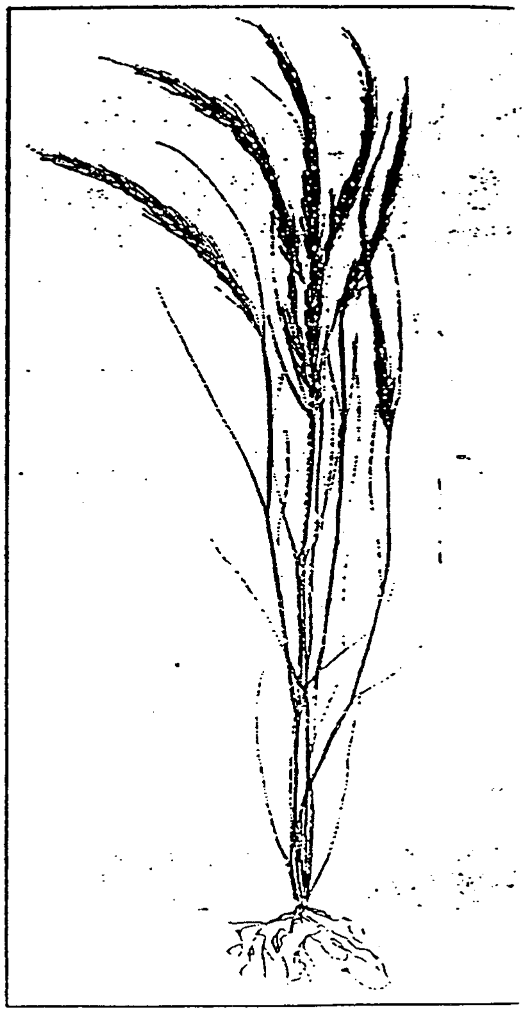
Plant materials are a significant component of about two-thirds of the conservation practices that farmers, ranchers and others find essential to the solution of erosion and sedimentation problems. It is SCS policy to assemble, evaluate, release and distribute for commercial increase, new or improved plant materials needed for resource conservation and development.

SCS assistance is available without regard to race, creed, color, sex, or national origin.

Revised January 1985

United States Department of Agriculture
Soil Conservation Service
Davis, California

'Zorro' Annual Fescue



'Zorro' Annual Fescue

(Vulpia myuros L.)

'Zorro' annual fescue was originally introduced into California during the Mission period. It was released by the Soil Conservation Service in cooperation with the California Agricultural Experiment Station in early 1977. This species occurs throughout California below 5,500 feet, and in Oregon, Washington, Idaho, Nevada, Arizona, Texas, and in several localities on the East Coast.

Description

'Zorro' is a short, aggressive, early maturing, cool-season annual grass with many fibrous roots. It has excellent seedling vigor, and emerges in fall very soon after the first rain. It matures seed earlier than most annual grasses, assuring perpetuation. It can tolerate soil problems of acidity, serpentine, and low fertility.

Adaptation

'Zorro' is a drought tolerant grass that will persist and provide good erosion control cover with an annual precipitation of at least 25cm (10 inches), or on areas receiving extra run-in moisture and on areas receiving some supplemental irrigation. It has persisted on sites up to 1365m (4,500 feet), and is suited to soils and mine spoils with a pH of 4.3 or higher. Its good seedling vigor and early growth make Zorro an excellent choice for obtaining fast cover with minimal seedbed preparation.

Uses

The excellent fibrous root system of 'Zorro' provides quick erosion control cover and soil stabilization to steep, shallow, infertile soils, and barren, disturbed slopes. As the site improves in condition, it will allow climax species to invade.

Its uses include road bank stabilization, wildfire burn and mine-spoil revegetation, orchard and vineyard cover crop, and problem soil control in the Mediterranean climate.

Establishment

The optimum time for seeding is between October 1 and November 15.

Loosening the soil surface before seeding and covering lightly produces the best stands. Seed ca be hydroseeded, but best establishment occurs when the seed is in contact with the soil.

Recommended seeding rates on critical areas are:

- Broadcast, hydroseeded — 12 pounds per acre
- Drilled — 6 pounds per acre
- Depth should be 1 to 2 cm (0.5 to 1 inch).

Seed can be drilled or broadcast, but because of its size and shape, it tends to stick together. Ric hulls and/or a good companion seed will help prevent "bridging over," and allow proper dispersio of seed. There are about 993,700 seeds per pound

Management

Applying 40 pounds of nitrogen per acre every other season during October or November will maintain healthy, erosion resistant stands. Annual fescues are initial invaders, so as sites improve, 'Zorro' will probably be replaced by taller, more enduring plants, unless the area is mowed or grazed. In cover crop planting, 'Zorro' can be mowed frequently, but should be allowed to mature seed for continued perpetuation. It is readily controlled by several herbicides, providing assurance that it will not become a troublesome weed.

Seed Availability

Foundation seed of 'Zorro' is available through the California Crop Improvement Association and local Resource Conservation Districts. Certified seed is available through several commercial outlets in California.

FERTILIZER SELECTION

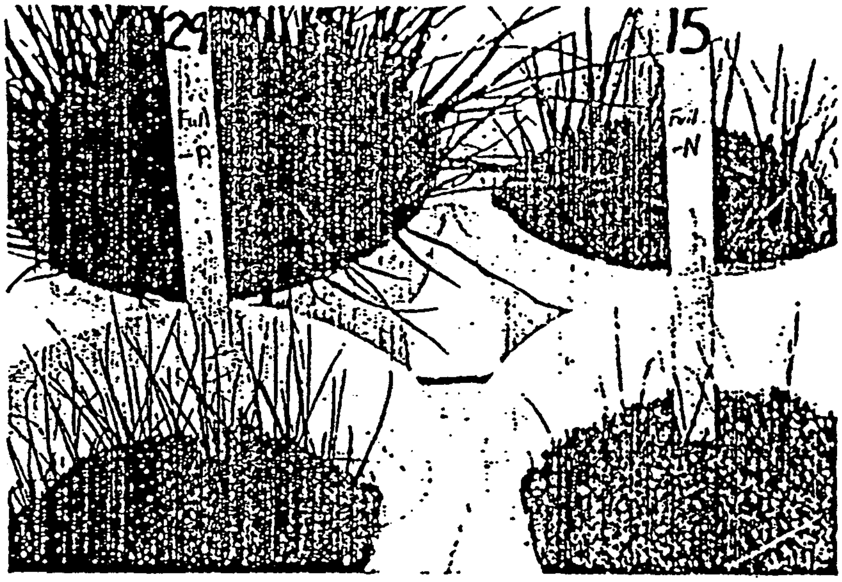


Fig. 6.17 Effect of nutrient omission on plant growth. (Courtesy of Burgess Kay)

Soil acidity, or pH, is another important variable for plant growth. Some plants require acid soils, and others require alkaline soils. If a soil is too acid for the desired plants, lime can be added to the fertilizer mix to raise the pH to the desired range. The lime may be in the form of pulverized dolomite or limestone.

Soil salinity is also a concern, particularly in arid climates and along roads where deicing salts are used. One solution to salinity problems is to choose salt-tolerant plants. An alternative is to improve drainage so that the salt will be leached from the soil.

The amount and composition of fertilizer to use depends on local soil conditions. The local farm adviser or soil conservation service office (Sec. 6.1d) should know the fertilizer requirements in your area. Chemical soil tests can also be used to determine nutrient needs on-site, although the tests can be costly and time-consuming. Because the chemical composition of a soil can vary significantly at different locations and depths on a single small site, a soil test can produce erroneous or misleading results.

Many state, regional, and local agencies have developed fertilizing specifications for use in their jurisdictions. In the San Francisco Bay Area, the recommended nutrient mix for temporary and permanent grass seeding is 500 lb/acre (568 kg/ha) of 16-20-0 (16 percent nitrogen, 20 percent phosphorus and 0 percent potassium) with 15 percent sulfur. (1) In Virginia, the recommended fertilizer for temporary erosion control seeding is 10-20-20 at 450 lb/acre (511 kg/ha). (16) Maryland's specifications call for 600 lb/acre (682 kg/ha) of 10-10-10. (10)

Source: Goldman, Jackson, Bursztnsky, "Erosion and Sediment Control Handbook," p. 6.22, McGraw Hill Publishers, 1986.

RED BROME—Bromus rubens L.
Grass Family

Red brome is a troublesome annual weed in California. It infests native pastures and has very little or no value as forage. It infests irrigated pastures, alfalfa, and cultivated crops, especially those planted during the winter and early spring. It is also found in orchards and vineyards, and along roadsides.

SEEDLING

In its seeding stage, red brome is very slender and difficult to distinguish from other fine-leaved grasses. The leaf blades and sheaths are covered with very short, fine, soft hairs. There are no earlike projections (auricles) at the bases of the leaves. Inside the leaf blades, where they join the sheath, the collarlike appendages (ligules) are long, pointed, and membranous, with torn or ragged edges.

MATURE PLANT

The mature plant is ½ to 1 ½ feet (15 to 45 cm) high.

Leaves: The leaves are narrow, and the leaf blades, sheaths, and stems are covered with very short, dense, soft hairs.

Flowers: The compact flowering heads (panicles) are 1 to 3 inches (2.5 to 7.5 cm) long and egg shaped in outline. They have 4 to 11 flowering bracts each ending in a reddish or purplish stiff bristle about ¾ to 1 inch (18 to 25 mm) long. At first the heads are greenish but they usually become reddish, probably the reason for the common name.

OTHER COMMON NAMES

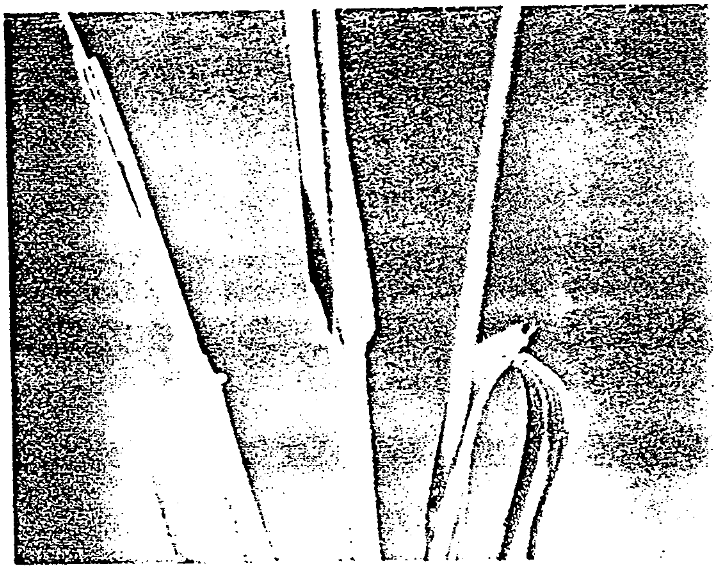
Foxtail brome, foxtail chess, tufted brome, and foxtail bromegrass.

PREPARED BY BILL B. FISCHER, FARM ADVISOR, FRESNO COUNTY; ARTHUR H. LANGE, WEED SCIENTIST;
BEECHER CRAMPTON, SR. AGRONOMY LECTURER AND SPECIALIST; AND JOYCE K. COX,
SR. EDITOR, AGRICULTURAL SCIENCES PUBLICATIONS; ALL ON THE STAFF OF THE UNIVERSITY OF CALIFORNIA.

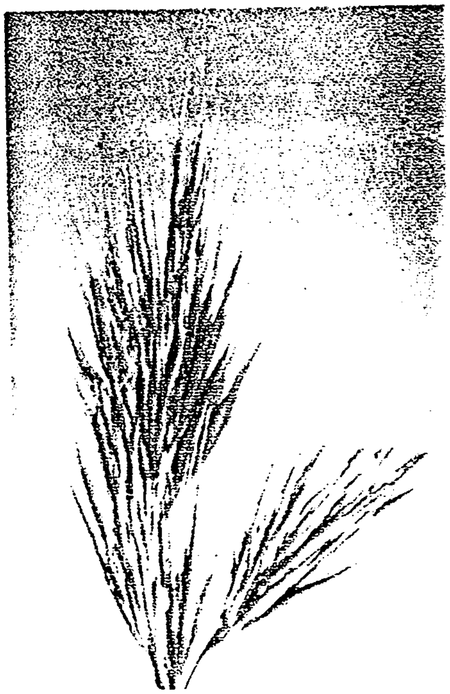
HANDBOOK - UC

RED BROME—*Bromus rubens* L.

MATURE PLANT



COLLAR REGION

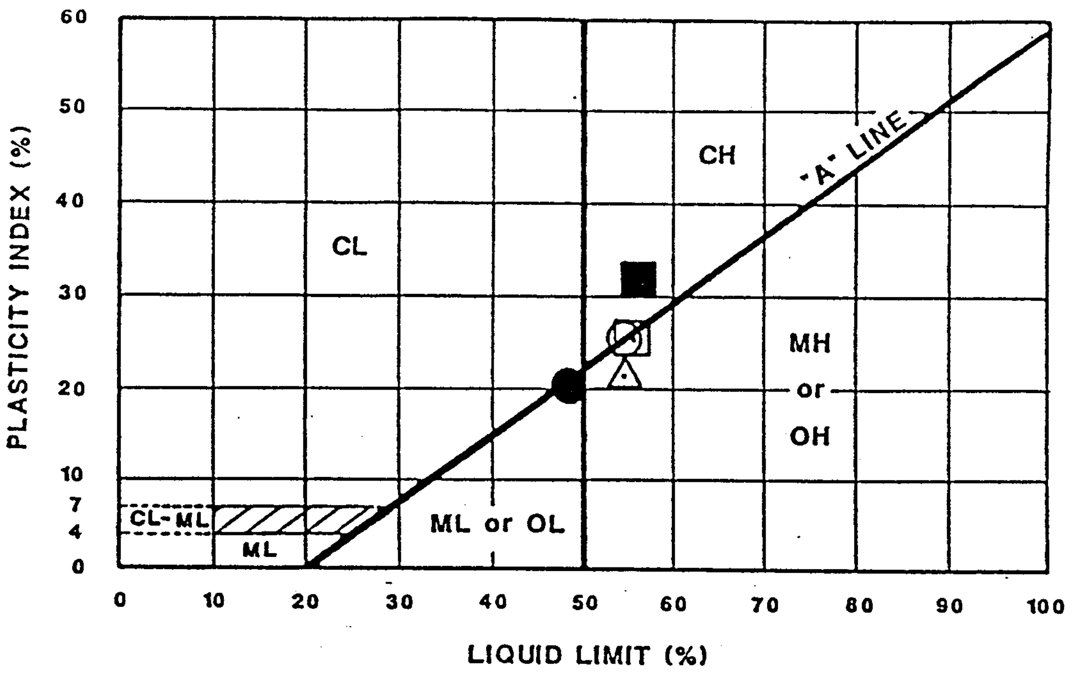


PANICLE

F.6 Laboratory Test Results

BY POG DATE 9-6-90 SUBJECT LLNL HE TEST PITS SHEET NO. ____ OF ____
CHKD. BY ____ DATE ____ LABORATORY TEST RESULTS JOB NO. ____

LLNL SITE 300
HE TEST PITS
LABORATORY TEST RESULTS



KEY SYMBOL	BORING NO.	SAMPLE DEPTH (FEET)	NATURAL WATER CONTENT %	ATTERBERG LIMITS			PASSING NO. 200 SIEVE %	UNIFIED SOIL CLASSIFI-CATION SYMBOL
				LIQUID LIMIT %	PLASTICITY INDEX %	LIQUIDITY INDEX %		
⊙	829-11	5.5'	29	55	25		-	MH-CH
⊡	829-12	1.5'	23	56	25		-	MH
◬	829-13	0.5'	31	55	22		69	MH
●	BS-3	SURFACE	18	49	22		79	ML
■	BS-4	CUTTINGS 829-13	26	57	31		72	CH

ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

PLASTICITY CHART AND DATA

LLNL SITE 300 HE BURN PITS

PROJECT NO.	DATE	Figure
CC0873.1T	9-4-90	

ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

SOIL COMPACTION TEST

Job No. CC0873.1T Project LLNL HE BURN PITS

Location of Project ____________ Sample No. BS1

Description of Soil ____________

Test Performed by FHC Date of Test 8-20-90

Mold Dimensions: Diam. 4 Ht. 4.6 Vol. 1/30 cf

Weight of Hammer ______ No.of Layers ______ Blows/Layer ______

Water Content

Sample No.	1	2	3	4	5
Can No.	B9	B4	B1	B2	B5
Wt. of Can + Wet Soil (1)	217.5	270.4	220.3	281.4	279.1
Wt. of Can + Dry Soil (2)	198.6	241.1	194.2	245.1	236.5
Wt. of Water (1)-(2) = (3)	18.9	29.3	26.1	36.3	42.6
Wt. of Can (4)	49.5	48.5	48.7	49.0	48.8
Wt. of Dry Soil (2)-(4) = (5)	149.1	192.6	145.5	196.1	187.7
Water Content, % (3)/(5)	12.68	15.21	17.94	18.51	22.7

Density

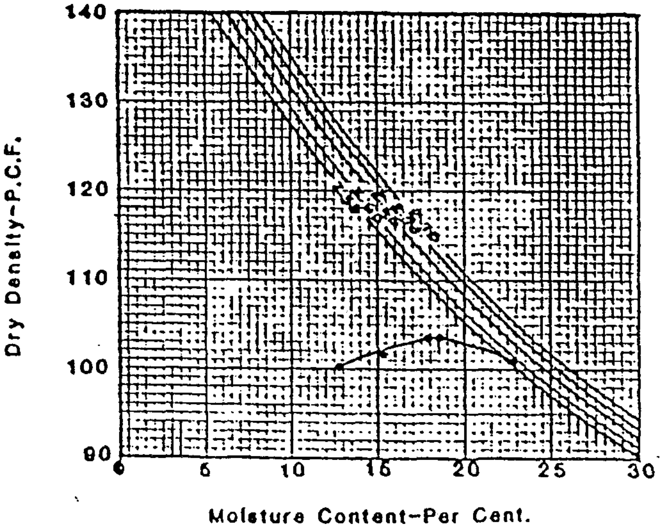
Water Content, %					
Wt. of Soil + Mold, g	3736.0	3800.3	3874.6	3883.7	3903.2
Wt. of Mold, g	2028.2	2028.2	2028.2	2028.2	2028.2
Wt. of Soil in Mold, g	1707.8	1772.1	1846.4	1855.5	1875.0
Wt. of Soil in Mold, lbs.	3.765	3.907	4.0706	4.0906	4.1336
Wet Density,pcf	112.95	117.2	122.12	122.72	124.01
Dry Density, pcf	100.24	101.73	103.54	103.55	101.07

Maximum Dry Density 103.5 psf

Optimum Moisture 18%

Soil Type ML

Curve Number ____________



ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

SOIL COMPACTION TEST

Job No. CC0873.1T Project LLNL HE BURN PITS
Location of Project ____ Sample No. BS2
Description of Soil ____
Test Performed by FHC Date of Test 8/21 - 8/23/90
Mold Dimensions: Diam. 4 Ht. 4.6 Vol. 1/30 cf
Weight of Hammer ____ No.of Layers ____ Blows/Layer ____

Water Content

Sample No.	1	2	3	4	
Can No.	B12	B11	B1	B10	
Wt. of Can + Wet Soil (1)	292.2	307.3	304.5	304.9	
Wt. of Can + Dry Soil (2)	245.6	285.0	272.5	267.5	
Wt. of Water (1)-(2) = (3)	46.6	22.3	32.0	37.4	
Wt. of Can (4)	48.7	49.2	48.7	48.5	
Wt. of Dry Soil (2)-(4) = (5)	196.9	235.8	223.8	219	
Water Content, % (3)/(5)	23.7	9.46	14.3	17.08	

Density

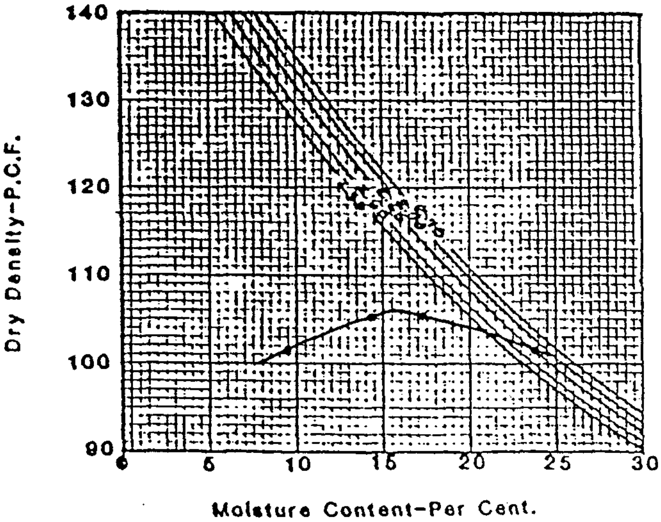
Water Content, %					
Wt. of Soil + Mold, g	3927.3	3708.2	3846.9	3897.5	
Wt. of Mold, g	2028.2	2028.2	2028.2	2028.2	
Wt. of Soil in Mold, g	1899.1	1680.0	1818.7	1869.1	
Wt. of Soil in Mold, lbs.	4.187	3.704	4.01	4.121	
Wet Density,pcf	125.6	111.11	120.285	123.619	
Dry Density, pcf	101.54	101.51	105.24	105.59	

Maximum Dry Density 106

Optimum Moisture 16%

Soil Type ML

Curve Number ____



ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

SOIL COMPACTION TEST

Job No. CC0873.1T Project LLNL HE BURN PITS

Location of Project ______ Sample No. BS3

Description of Soil ______

Test Performed by FHC Date of Test 8/21 - 8/22/90

Mold Dimensions: Diam. 4 Ht. 4.6 Vol. 1/30 cf

Weight of Hammer ______ No. of Layers ______ Blows/Layer ______

Water Content

Sample No.	1	2	3	4	
Can No.	B7	B8	B6	B2	
Wt. of Can + Wet Soil (1)	280.2	274.5	288.2	275.2	
Wt. of Can + Dry Soil (2)	248.9	240.1	247.7	253.0	
Wt. of Water (1)-(2) = (3)	31.3	34.4	40.5	22.2	
Wt. of Can (4)	48.6	49.4	48.6	49.0	
Wt. of Dry Soil (2)-(4) = (5)	200.3	190.7	199.1	204.0	
Water Content, % (3)/(5)	15.63	18.04	20.34	10.78	

Density

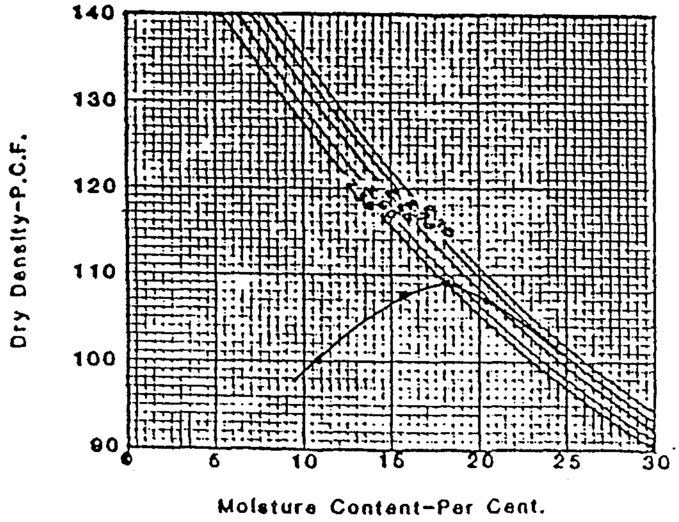
Water Content, %					
Wt. of Soil + Mold, g	3915.0	3975.4	3977.4	3706.2	
Wt. of Mold, g	2028.2	2028.2	2028.2	2028.2	
Wt. of Soil in Mold, g	1886.8	1947.2	1949.2	1678.0	
Wt. of Soil in Mold, lbs.	4.1596	4.2928	4.2972	3.699	
Wet Density, pcf	124.79	128.784	128.916	110.98	
Dry Density, pcf	107.92	109.1	107.13	100.18	

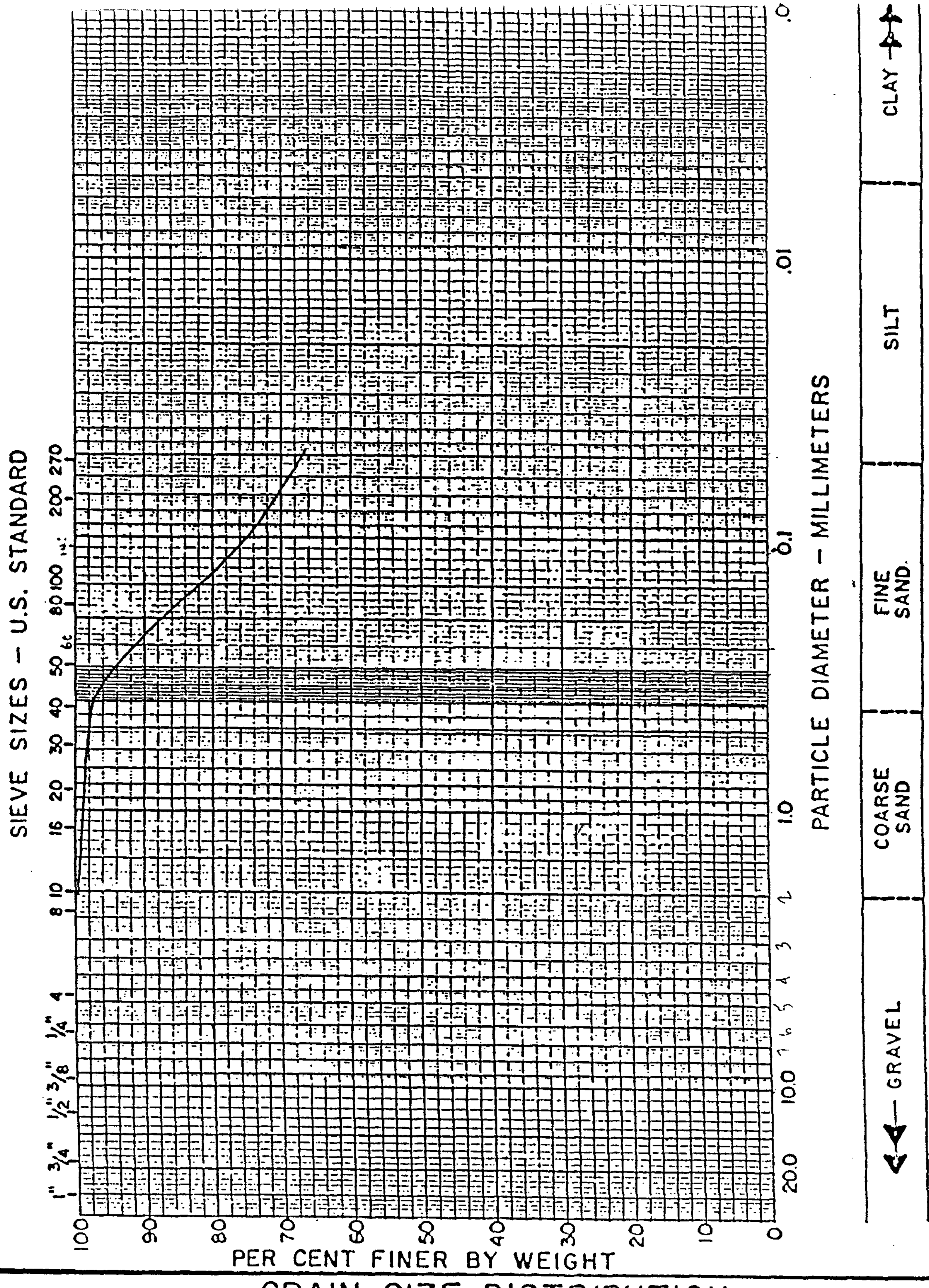
Maximum Dry Density 109

Optimum Moisture 18%

Soil Type ML

Curve Number ______





NO. 829-13

DEPTH 0.5' - 1.0' FT.

L.L. 55

P.I. 22

UNIFIED CLASS

A.A.S.H.O. CLASS

GRAIN SIZE DISTRIBUTION

By: FHC Date: 8/16/90

J.N. CC0873.1T

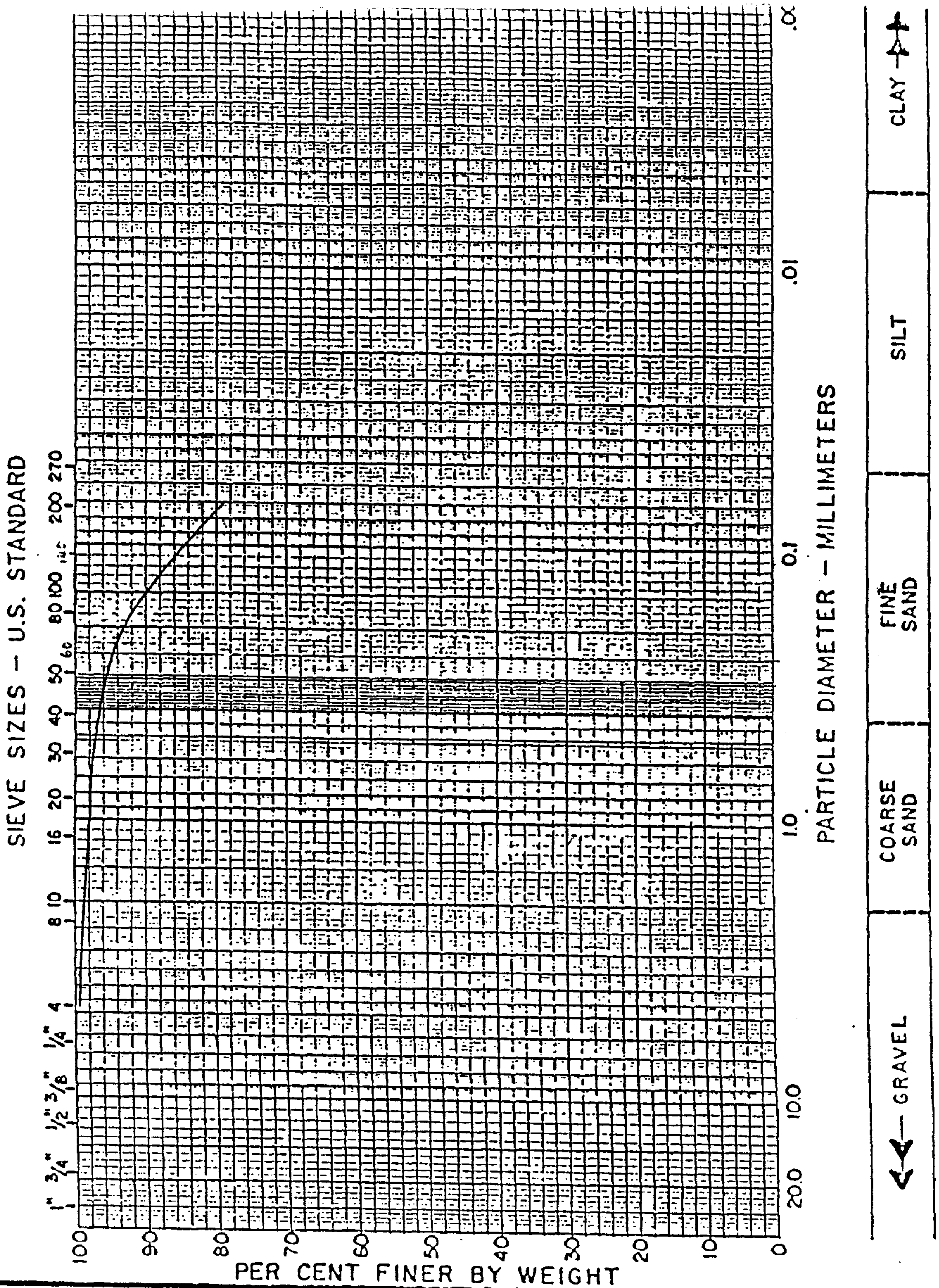
ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

Figure

Job Title: LLNL HE BURN PITS

F-18

Job Location:



UNIFIED CLASS

A.A.S.H.O. CLASS

L.L. 49

P.I. 22

NO. BS3

DEPTH FT.

GRAIN SIZE DISTRIBUTION

By: FHC Date: 8/16/90

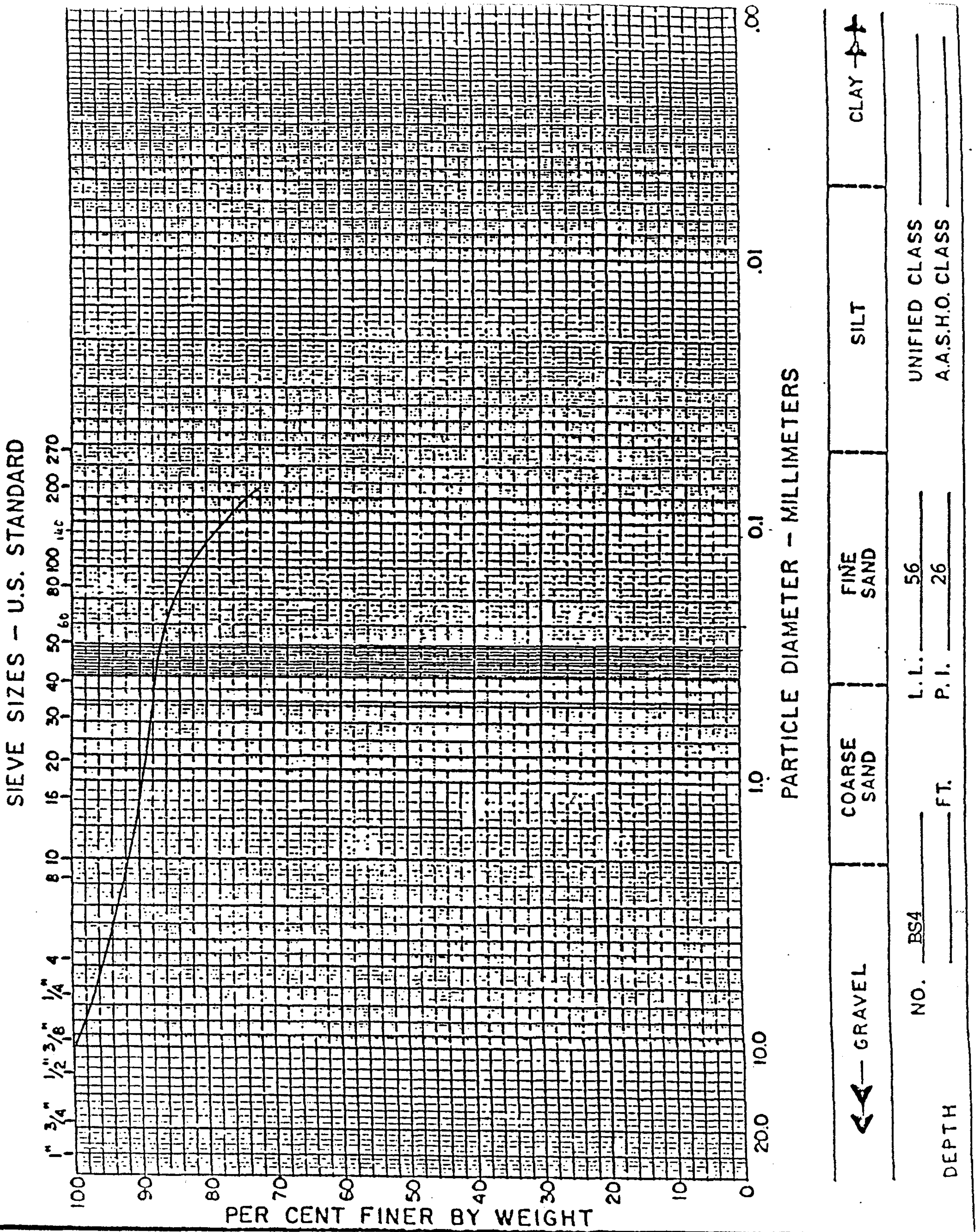
J.N. CC0873.1T

ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

Figure

Job Title: LLNL HE BURN PITS

Job Location:



UNIFIED CLASS

A.A.S.H.O. CLASS

L.L. 56

P.I. 26

NO. BS4

DEPTH FT.

GRAIN SIZE DISTRIBUTION

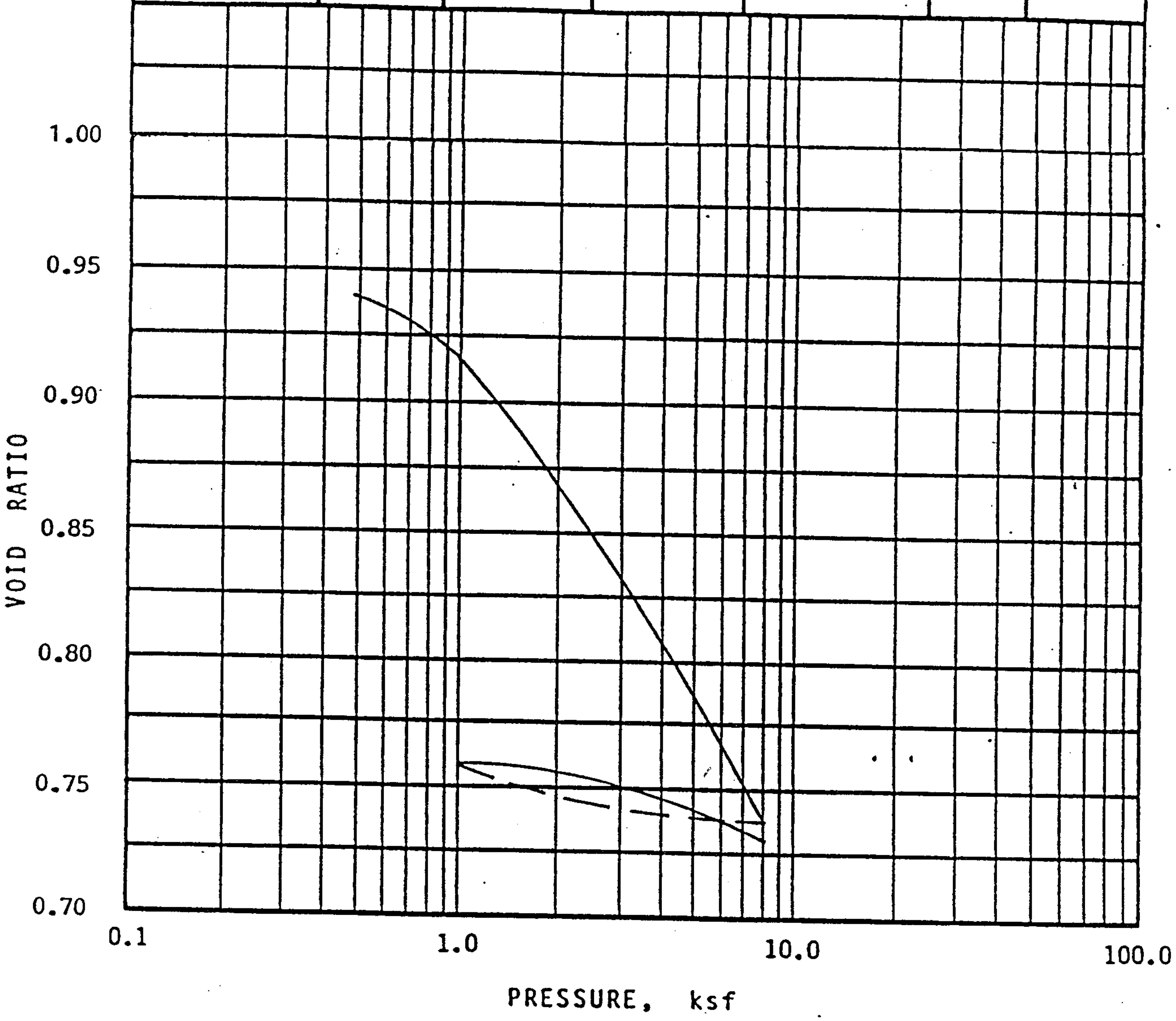
By: FHC Date: 8/16/90	ROGERS/PACIFIC PROFESSIONAL ENGINEERING CONSULTANTS	Figure
J.N. CC0873.1T		

Job Title: LLNL HE BURN PITS

F-20

Job Location:

SAMPLE NO.	SUMMARY OF TEST RESULTS					
	SPECIFIC GRAVITY	MOISTURE CONTENT, (%)	DRY DENSITY, (PCF)	PERCENT OF SATURATION, (%)	HEIGHT (IN.)	DIAMETER (IN.)
INITIAL						
FINAL						



Project Name LLNL HE BURN PITS

Job Number CC0873.1T

Tested By FHC Date 8/18/90

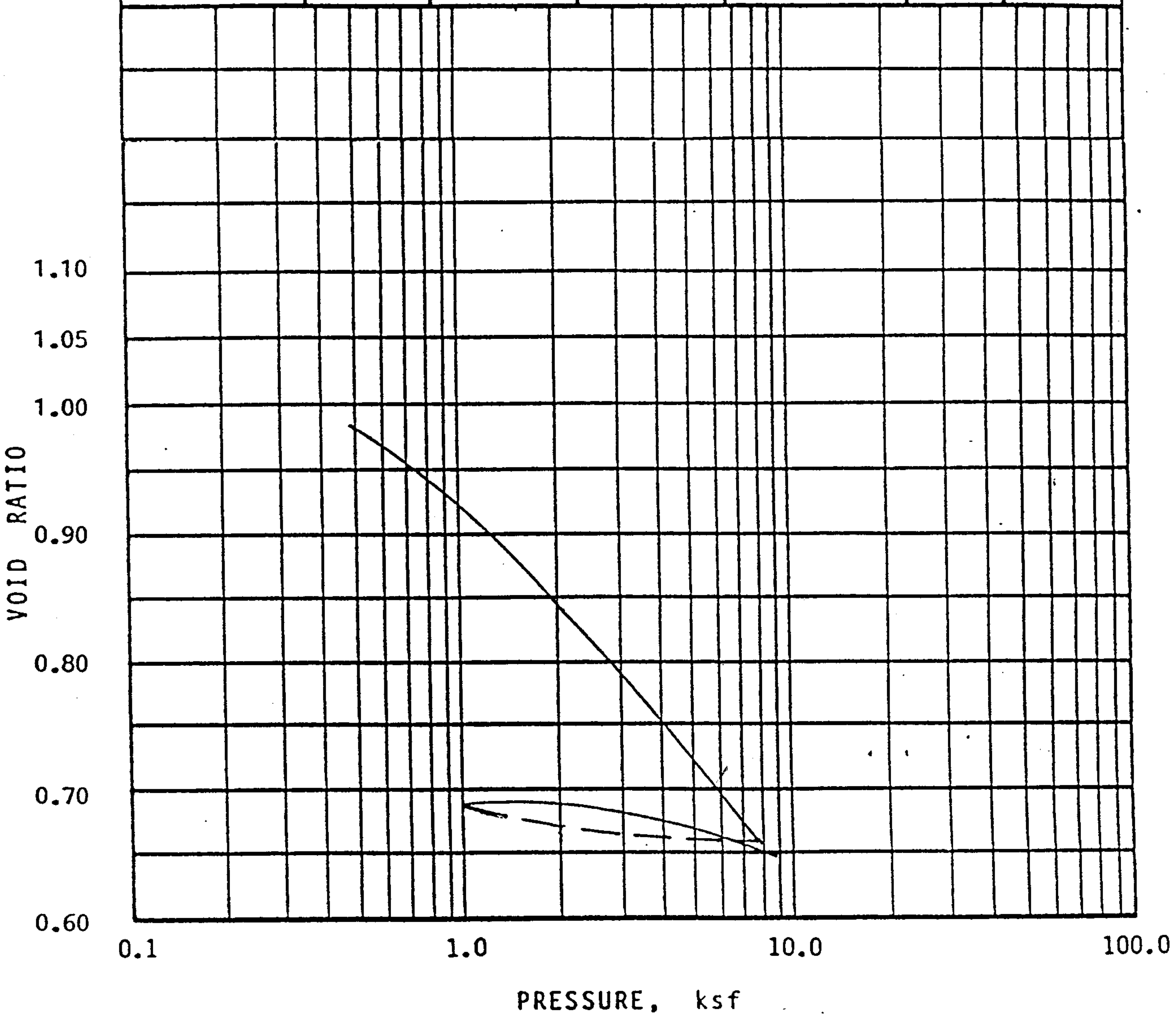
ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

829-13 1.5'-2.0'

LLNL SITE 300 HE BURN PITS

PROJECT NO.	DATE	Figure
CC0[illegible]	8-18-90	

SAMPLE NO.	SUMMARY OF TEST RESULTS					
	SPECIFIC GRAVITY	MOISTURE CONTENT, (%)	DRY DENSITY, (PCF)	PERCENT OF SATURATION, (%)	HEIGHT (IN.)	DIAMETER (IN.)
INITIAL						
FINAL						



Project Name LLNL HE BURN PITS

Job Number CC0873.1T

Tested By FHC Date 8/18/90

ROGERS/PACIFIC
PROFESSIONAL ENGINEERING CONSULTANTS

829-11 5.5'-6.0'

LLNL SITE 300 HE BURN PITS

PROJECT NO.	DATE	Figure
CC0873 1T	8/18/90	

Supplement F.I.

Static Settlement

BY POG DATE 9-6-90 SUBJECT LLNL HE TEST PITS SHEET NO. ____ OF ____

CHKD. BY WMS DATE 9-6 90 SETTLEMENT ANALYSIS JOB NO. CC0873.1T

LLNL SITE 300
HE TEST PITS
SETTLEMENT ANALYSIS

BY POG DATE 9-6-90 SUBJECT LLNL HE TEST PITS SHEET NO. 1 OF
CHKD. BY DATE SETTLEMENT CALCULATIONS JOB NO. CC0873.IT

SUMMARY

AN ANALYSIS OF PREDICTED SETTLEMENTS HAS BEEN PERFORMED FOR THE PROPOSED HE BURN PITS DISPOSAL CELL AT LLNL SITE 300. THE ANALYSIS IS BASED ON THE RESULTS OF AN EXPLORATORY DRILLING PROGRAM AND LAB TESTING PROGRAM PERFORMED FOR THIS PROJECT. IN ADDITION, THE RESULTS OF LABORATORY TESTING PERFORMED FOR A CLAY CAP BORROW SOURCE TO BE USED AS PART OF THE DISPOSAL CELL FOR SITE 300 DISPOSAL PITS 1 ! 7 WERE USED IN THE ANALYSIS.

THE MAXIMUM AMOUNT OF SETTLEMENT SHOULD OCCUR IN THE SOUTHEAST PORTION OF THE BURN PITS SITE WHERE THE DEPTH OF FILL IS THE GREATEST. IT IS ESTIMATED THAT APPROXIMATELY ONE INCH (1") OF TOTAL STATIC SETTLEMENT WILL OCCUR IN THIS AREA AS A RESULT OF CONSOLIDATION OF THE EXISTING FILL AND CAP MATERIALS.

AT THE SOUTH PERIMETER OF THE CELL, BASICALLY <u>NO</u> SETTLEMENT IS EXPECTED TO OCCUR. THE PERIMETER IS ABOUT 20 FEET FROM THE AREA WHERE 1" OF SETTLEMENT IS EXPECTED. THIS EQUATES TO A DIFFERENTIAL SETTLEMENT OF 1/240 AND EQUATES TO A LOW LEVEL OF SETTLEMENT-INDUCED STRAIN IN THE COVER SYSTEM.

PLEASANT HILL, CALIFORNIA

BY JDG DATE 9-4-90 SUBJECT LLNL HE TEST PITS SHEET NO. 1 OF
CHKD. BY WMS DATE 9-6-90 SETTLEMENT ANALYSIS JOB NO. CC0873.IT

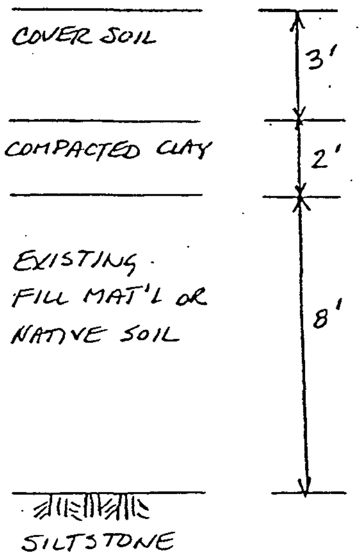
PURPOSE: TO ESTIMATE THE TOTAL SETTLEMENT OF EXISTING BURN PIT MATERIALS AND FINAL COVER COMPONENTS FOR THE FINAL COVER FOR SITE 300 HE TEST PITS.

METHOD: ONE DIMENSIONAL TERZAGHI CONSOLIDATION THEORY WILL BE USED TO DETERMINE THE ULTIMATE SETTLEMENT. (REF. 1)

DISPOSAL CELL CONFIGURATION:

- FROM DISCUSSIONS WITH WEISS ASSOC. PROJECT ENGR. (8-27-90 PHONE CONVERSATION W/ LISSA MINER) A CAP W/ A MINIMUM THICKNESS OF 5' WILL BE USED. A PLAN VIEW OF THE EXISTING SITE IS SHOWN ON SHT. 2; A REPRESENTATIVE CROSS-SECTION OF THE EXISTING SITE AND PROBABLE CAP CONFIGURATION IS GIVEN ON SHT. 3.

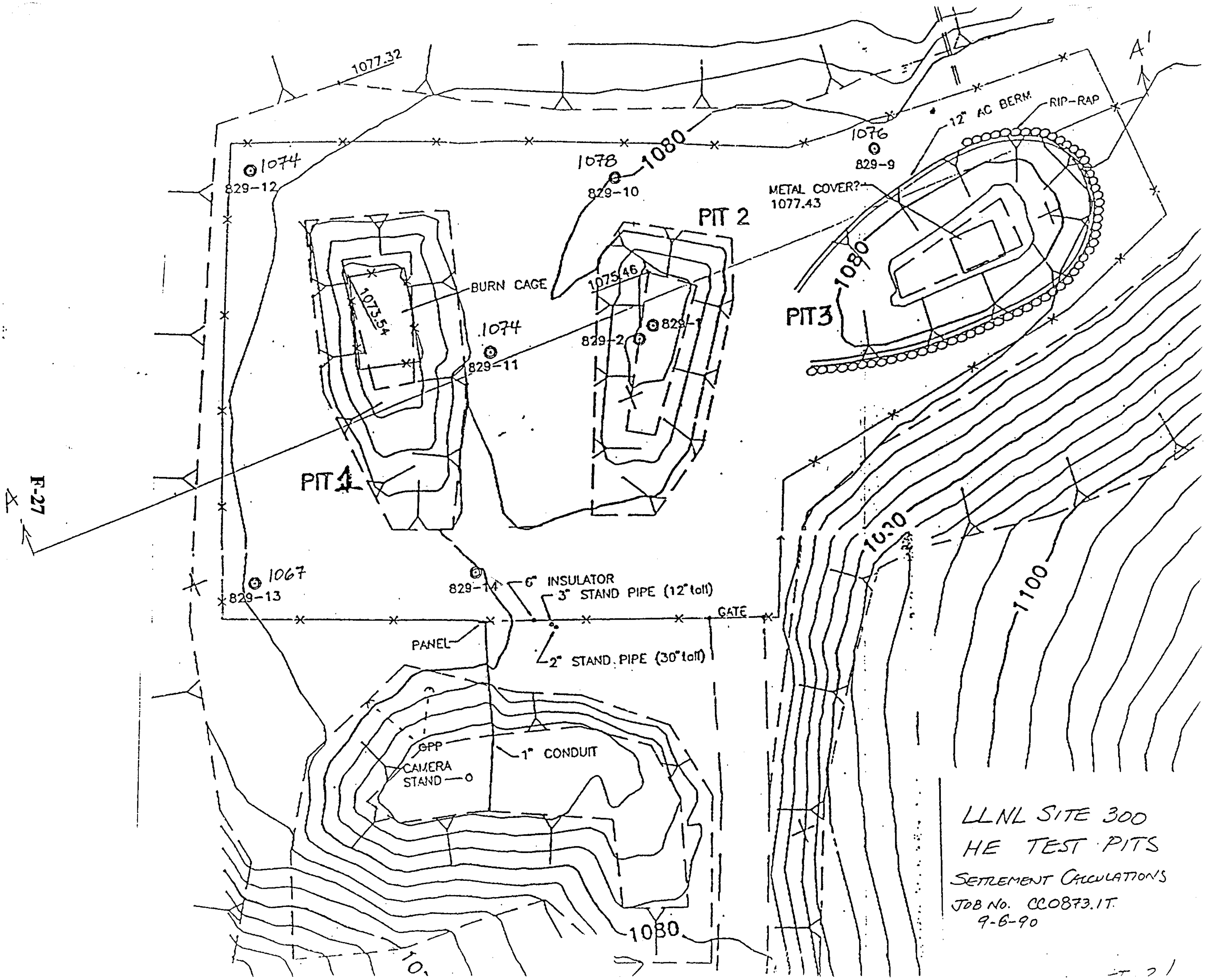
- THE AREA OF THE DISPOSAL CELL WHICH SHOULD EXHIBIT THE GREATEST SETTLEMENT IS LOCATED @ THE SOUTH END OF CELL #1. WHERE THE DEPTH TO SILTSTONE FROM THE EXISTING GROUND SURFACE IS THE GREATEST. AN IDEALIZED SOIL COLUMN FOR SETTLEMENT CALCULATIONS IS GIVEN BELOW FOR THIS LOCATION.



ANALYSIS:

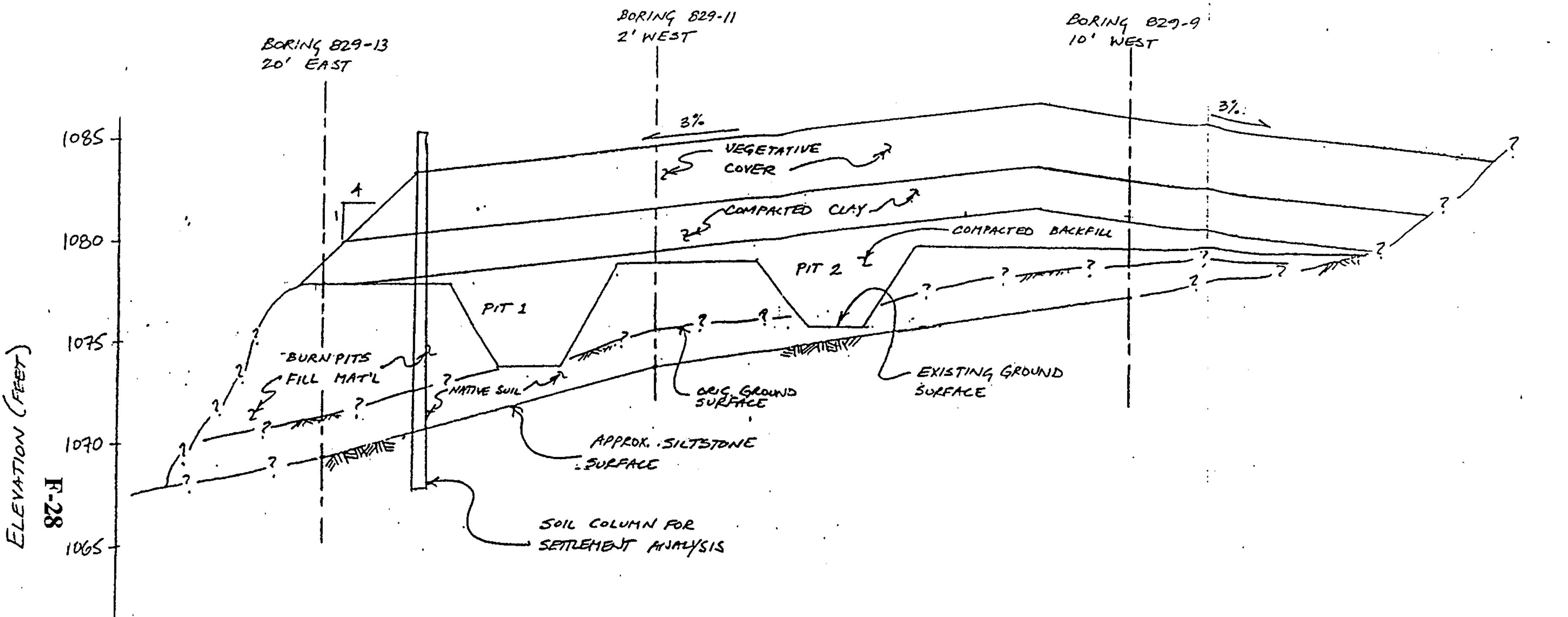
- BECAUSE THERE ARE NO GRANULAR MATERIALS PRESENT, CONSOLIDATION SETTLEMENT WILL BE THE ONLY SIGNIFICANT SOURCE OF SETTLEMENT. ELASTIC SETTLEMENT OF COHESIVE SOILS IS ASSUMED TO BE NEGLIGIBLE.

- IT IS ASSUMED THAT NO SETTLEMENT WILL OCCUR IN THE COVER SOIL (VEGETATION LAYER) AND THAT IF ANY SETTLEMENT WERE TO OCCUR IT WOULD BE MINOR AND WOULD NOT ADVERSELEY EFFECT THE INTEGRITY OF THE CLAY CAP.



LLNL SITE 300
HE TEST PITS
SETTLEMENT CALCULATIONS
JOB NO. CC0873.1T.
9-6-90

1C1430



CROSS SECTION A-A

SCALE FEET
0 20 40 HORIZONTAL
0 5 10 VERTICAL

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LLNL SITE 300 HE TEST PITS

SETTLEMENT CALCULATIONS CROSS-SECTION

SCALE: NOTED	JOB NUMBER	DRAWN BY	FIGURE NUMBER
DATE: 9-6-90	CC0873.1T	PDG	SHEET 3/

BY POG DATE 9-5-90 SUBJECT LLNL HE TEST PITS SHEET NO. 4 OF 7
CHKD. BY WMS DATE 9-6-90 SETTLEMENT ANALYSIS JOB NO. CC0873.IT

SOIL PARAMETERS: THE FOLLOWING SOIL PARAMETERS WERE DEVELOPED FOR EACH SOIL LAYER, AS DISCUSSED BELOW:

γ_d = dry unit weight of soil
γ_m = moist unit weight of soil
P_p = pre-consolidation pressure of soil
C_c = compression index
C_r = recompression index
C_{EC} = compression ratio = $\frac{C_c}{1+e_o}$
C_{ER} = recompression ratio = $\frac{C_r}{1+e_o}$
e_o = initial void ratio

A) COVER SOIL:

γ_d = 104 pcf
γ_m = 119 pcf

} assumptions based on use of an SC-ML (sandy loam) cover soil

P_p = N/A
C_c = N/A
C_R = N/A
C_{EC} = N/A
C_{ER} = N/A
e_o = N/A

B) COMPACTED CLAY LAYER:

IT IS ASSUMED THAT THE COMPACTED CLAY LAYER WILL CONSIST OF COMPACTED IONE CLAY AS IS PROPOSED FOR CAPPING OF LLNL SITE 300 PITS 1 & 7 (REF. 2). BASED ON TESTING PERFORMED FOR THAT STUDY,

γ_d = 99 pcf
γ_m = 121 pcf
P_p = 2200 psf
C_c = 0.26
C_R = 0.04
e_o = 0.69

$C_{ER} = \frac{0.04}{1.69} = 0.024$

$C_{EC} = \frac{0.26}{1.69} = 0.154$

BY POG DATE 9-5-90 SUBJECT LLNL HE TEST PITS SHEET NO. 5 OF 7
CHKD. BY WMS DATE 9-6-90 SETTLEMENT ANALYSIS JOB NO. CC0873.1T

C) EXISTING FILL/NATIVE:

BASED ON THE RESULTS OF DRILLING AND LABORATORY TESTING, THE NATIVE SOILS AND FILL PLACED TO ORIGINALLY CONSTRUCT THE BURN PITS FACILITY ARE IDENTICAL FOR ALL PRACTICAL PURPOSES. FOR THE PURPOSE OF THIS ANALYSIS, THEY WILL BE ASSUMED TO BE ONE UNIT WITH THE FOLLOWING PROPERTIES BASED ON LABORATORY TESTS:

$\gamma_d = 81$ pcf
$\gamma_m = 104$ pcf
$P_p = 1100$ psf
$C_c = 0.25$
$C_R = 0.035$
$e_o = 0.99$
$C_{\epsilon c} = 0.126$
$C_{\epsilon R} = 0.018$

D) SILTSTONE — ASSUMED TO BE INCOMPRESSIBLE RELATIVE TO THE LOW STRESS INCREASES

COMPUTATION OF VERTICAL SETTLEMENT:

SETTLEMENT WILL BE CALCULATED USING TERZAGHI CONSOLIDATION THEORY (REF. 1) FOR TWO COMPONENTS, CONSOLIDATION OF THE EXISTING FILL/NATIVE SOIL LAYER AND CONSOLIDATION OF THE COMPACTED CLAY LAYER.

A) NATIVE SOIL LAYER:

1) check to see if soil is overconsolidated or if it will remain so:

- @ the center of the clay layer, the existing
$P_o = 4'(104 \text{ pcf}) = 416 \text{ pcf}$

- after placement of the clay cover and soil cover:
$P_f = 416 \text{pcf} + 2(121) + 3(119) = 1015 \text{ pcf}$

since $P_p = 1100 \text{pcf} > P_f$ the layer will remain over consolidated

2) since the layer will remain overconsolidated:

$$\varepsilon_z = C_{\varepsilon R} \log \frac{P_f}{P_o}$$

and $\Delta H_A = \varepsilon_z H_o = C_{\varepsilon R} \log \frac{P_f}{P_o} H_o = 0.018 \log \frac{1015}{416} (8 ft)$

$= 0.67$ inches

B) COMPACTED CLAY LAYER:

1) check to see if soil is o.c. and if it will remain so:

- @ center of clay layer

$P_o = 1'(121) = 121$ psf

-after placement of the clay cover and soil cover:

$P_f = 121 + 3(119) = 478$ psf

- since $P_p = 2200$ psf $> P_f$ the layer will remain O.C.

2) since the layer will remain O.C.

$$\varepsilon_z = C_{\varepsilon R} \log \frac{P_f}{P_o}$$

$\Delta H_B = \varepsilon_z H_o = C_{\varepsilon R} \log \frac{P_f}{P_o} H_o = 0.024 \log \frac{478}{121} (2 ft)$

$= 0.34$ inches

C) TOTAL SETTLEMENT: (A)+(B)

TOTAL $\Delta H = \Delta H_A + \Delta H_B = 0.67 + 0.34 = 1.01$ inches

≈ 1" total settlement

PLEASANT HILL, CALIFORNIA

BY POG DATE 9-6-90 SUBJECT LLNL HE TEST PITS SHEET NO. 7 OF 7

CHKD. BY WMS DATE 9-6-90 SETTLEMENT ANALYSIS JOB NO. CC0873.1T

REFERENCES:

1. 'Duncan, J.M. and Buchignani, A.L., "An Engineering Manual For Settlement Studies," University of California, Berkeley, Department of Civil Engineering, 1976.

2. Rogers/Pacific, Inc., "Closure and Post-Closure Plans Landfill Pits 1 and 7, Lawrence Livermore National Laboratory, 1990 EPA ID Number CA 2890090002

CALCULATION SHEET

Sheet No. 1 of 3

Project No. 10-300-810

By FLM Date 4/19

Chkd. By Date

WEISS ASSOCIATES

SUBJECT: HE BURN PITS, SITE 300
CLOSURE PLANS
FML Integrity

I. BIAXIAL STRESS VIA SUBSIDENCE

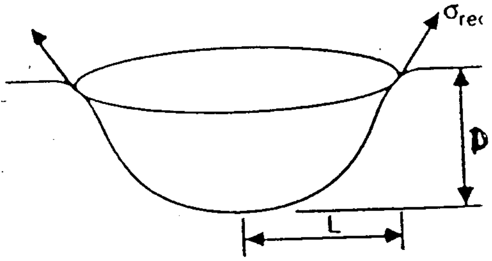
A. $\sigma_{req'd} = \frac{2 D L^2 \gamma_{cs} H_{cs}}{3 t (D^2 + L^2)}$; $F_S = \frac{\sigma_{allow}}{\sigma_{req'd}}$

γ_{cs} = unit wt of cover soil

H_{cs} = height of cover soil

t = geomembrane thickness

D, L = measurements in figure



B. STRESS DUE TO STATIC SETTLEMENT:

$\gamma_{cs} = 145\ lb/ft^3$

$H_{cs} = 3ft$

$t = 0.04''/12''$

$D = 1''/12''$

$L = 2ft$

Source: EPA Seminar Publication
Design and Construction
of RCRA/CERCLA Covers
EPA 625/4-91/025 May 91

$$\sigma_{req'd} = \frac{2\left(1/12\right)\cdot 2^2 \cdot 145 \cdot 3}{3\left(.04/12\right)\left(\left(1/12\right)^2 + 2^2\right)} = 7{,}237\ lb/ft^2 \cong 50psi$$

σ_{allow} = 1000 to 1684 per EPA guidance and Mfr. specs.

$\therefore$ FS ≅ 20 to 33 > 1 OK.

Sheet No. 2 of 3

Project No. 10-300-810

By ELM Date 9/19

Chkd. By ______ Date ______

SUBJECT: HE BURN PIT, SITE 300
CLOSURE PLAN
FML Integrity

C. STRESS DUE TO LOCAL DEPRESSION

$\gamma_{cs} = 145$

$H_{cs} = 3 ft$

$t = 0.04/12$

$D = 1$

$L = 2$

$$\sigma_{req'd} = \frac{2 \cdot 1 \cdot 2^2 \cdot 145 \cdot 3}{3(0.04/12)(1^2 + 2^2)} = 69{,}600 \, lb/ft^2 = 483 \, psi$$

$\sigma_{allow} = 1000$ to 1684

$FS = 2$ to $3.5 > 1.0$ OK.

3 of 3

ferent geomembranes have been reported in EPA's technical resources document as follows:

PVC	- 10 mil - 4.4 ml/m^2-day-atm.
	- 20 mil - 3.3 ml/m^2-day-atm.
LLDPE (linear low density polyethylene)	
	- 18 mil - 2.3 ml/m^2-day-atm.
CSPE	- 32 mil - 0.27 ml/m^2-day-atm.
	- 34 mil - 1.6 ml/m^2-day-atm.
HDPE	- 24 mil - 1.3 ml/m^2-day-atm.
	- 34 mil - 1.4 ml/m^2-day-atm.

Biaxial Stresses via Subsidence

As the waste beneath the closure subsides, differential settlement is likely to occur. Thus a factor-of-safety formulation of FS = $\sigma_{allow}/\sigma_{reqd}$ is necessary. This situation has been modeled (see Appendix A, *Stability and Tension Considerations Regarding Cover Soils on Geomembrane Lined Slopes*), giving rise to the following formula for required strength (σ_{reqd}):

$$\sigma_{reqd} = \frac{2\,D\,L^2\,\gamma_{cs}\,H_{cs}}{3\,t\,(D^2 + L^{2)}}$$

where γ_{cs} = unit weight of cover soil

H_{cs} = height of cover soil

t = thickness of geomembrane

D, L = see Figure 3-1

The allowable strength σ_{allow} of the candidate geomembrane must be evaluated in a closely simulated test, e.g., GRI's GM-4 entitled "Three Dimensional Geomembrane Tension Test." Figure 3-2 presents the response to this test of a number of common geomembranes used in closure situations.

Planar Stresses via Friction

In addition to the above out-of-plane stresses, the cover soil over the geomembrane might develop greater frictional stresses than the soil material beneath it. This happens particularly if a wet-of-optimum clay is placed beneath. Again a factor-of-safety formulation is formed by comparing the allowable strength (T_{allow}) to the required strength (T_{reqd}) but now in force units rather than stress units, e.g., FS = T_{allow}/T_{reqd}. The required geomembrane tension can be obtained by the equation given in Figure 3-3 (see Appendix A for a more detailed discussion).

where c_{aU}, c_{aL} = adhesion of the material upper and lower of the geomembrane

δ_U, δ_L = friction angle of the material upper and lower of the geomembrane

ω = slope angle

L = slope length

W = unit width of slope

γ_{cs} = unit weight of cover soil

H_{cs} = height of cover soil

When calculated, the value of T_{reqd} in Figure 3-3 is compared to the T_{allow} of the candidate geomembrane. This value is currently taken from ASTM D-4885, the wide-width tensile test for geomembranes. Note that this value must be suitably adjusted for creep, long-term degradation, and any other site-specific situations that are considered relevant.

GEONET AND GEOCOMPOSITE SHEET DRAIN DESIGN CONCEPTS

Geonets and/or geocomposite drains are often used as surface water drains located immediately above the geomembrane in a landfill closure system. There are three aspects to the design that require attention: material compatibility, crush strength, and flow capability.

Compatibility

Since the liquid being conveyed by the geonet or drainage geocomposite is water, EPA 9090 testing is usually not warranted. The polymers from which these products are made are polyethylene (PE), polypropylene (PP), high-impact styrene (HIS) or other long-chain molecular structures that have good water resistance and long-term durability when covered by soil.

Crush Strength

The crush strength of the candidate product must be evaluated by comparing an allowable strength to a required stress, i.e., FS = $\sigma_{allow}/\sigma_{reqd}$. The allowable strength is taken as the rib lay-down for geonets and the telescoping crush strength for drainage geocomposites. Figure 3-4 illustrates common behavior for geonets and geocomposites. The test methods currently recommended are GRI GN-1 for compression behavior of geonets and GRI GC-4 for drainage geocomposites, i.e., for sheet drains.

The required stress is the dead load of the cover soil plus any live loads that may be imposed, such as construction and maintenance equipment.

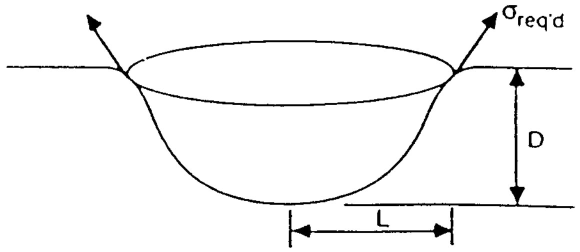


Figure 3-1. Required strength.

EPA 625/4-91/025 May 91

Supplement F.II.

Drainage Ditch Design

DESIGN FLOW, RATIONAL METHOD
RUNOFF FROM HE BURN PITS DRAINAGES

WEISS ASSOCIATES
Environmental Consulting

OBJECTIVE: CALCULATE DESIGN FLOW RUNOFF (cfs)

DEFINITIONS: Q = FLOW RATE (cfs)

C = RATIONAL EQUATION RUNOFF COEFFICIENT

I = DESIGN RAINFALL INTENSITY (in/hr.), PMP

A = WATERSHED AREA (ACRES)

ASSUMPTIONS:
(1) Entire watershed area used to generate flow.
(2) Peak flow occurs with PMP for T_c.
(3) Small area (< 100 acres)

METHOD: RATIONAL EQ, $Q = CIA$

DATA: $C = 0.60$, upper end for agricultural, bare packed soil, smooth, 0-30% slope. From "Erosion + Sediment Control Handbook" by Goldman, Jackson + Burstynsky, 1986

I = Design rainfall (PMP / time interval)

T_c = Time of Concentration (min. or hr.) for all parts of a watershed to contribute runoff from the design storm.

L = Length of longest overland flow path (ft)

H = Elevation Differential over longest flow path (ft)

Design I = Maximum precipitation that corresponds to the time of concentration

PMP = Probable maximum precipitation

PROJ. 10-500-57
BY ELM 10/7/90 ESL 10/23/90

PG 1/13

DESIGN FLOW, RATIONAL METHOD

RUNOFF FROM HE BURN PITS DRAINAGES

Calculation of Design Rainfall, I (cont)

ASSUMPTIONS + METHODS

(1) STATE OF CALIFORNIA, DEPT. OF WATER RESOURCES, "RAINFALL DEPTH - DURATION - FREQUENCY FOR CALIFORNIA," DATA FROM STATION, LIVERMORE 5NE AC24, PMP DATA FOR SHORT DURATION STORMS (CONSERVATIVE)

(2) TIME OF CONCENTRATION MAY USE SOIL CONSERVATION SERVICE (SCS) OR CAL HWY METHODS PUBLISHED IN BUREAU OF RECLAMATION, "DESIGN OF SMALL DAMS 1977 ed., FIGURE 3D (Attached)

DATA: PMP; LIVERMORE 5NE AC24 STATION

5 PMP = 0.89"
10 PMP = 1.18"
15 PMP = 1.34"
30 PMP = 1.73"
60 PMP = 2.67"

} DESIGN RAINFALL EVENT

$L = 600$

$H = 102.5'$

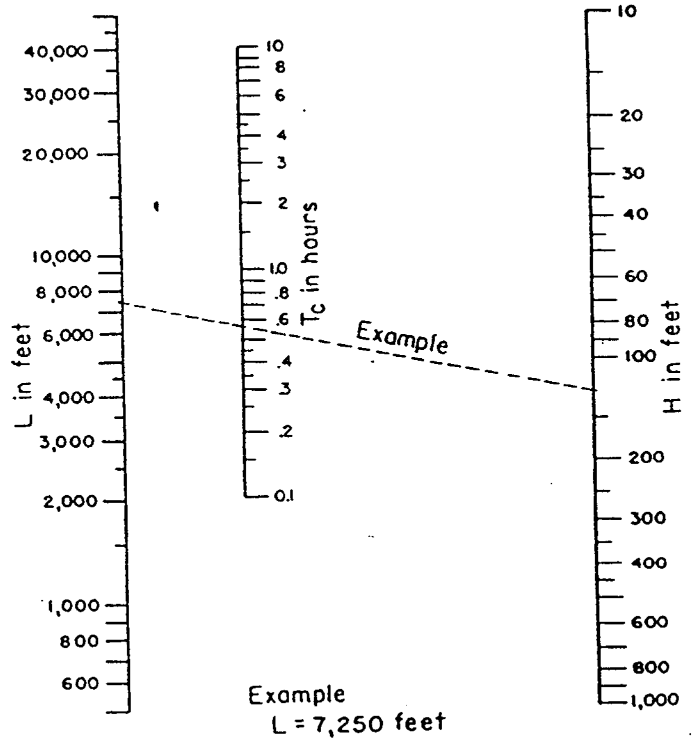
SCS Nomograph. $T_c = 0.21\ hr \times 60 \frac{min}{hr} = 12.6 min$

$$T_c = \left(\frac{11.9 L^3}{H}\right)^{0.385} = \left(\frac{11.9\ (600/5280)^3}{102.5}\right)^{0.385}$$

$T_c = 0.035\ hr \times \frac{60 min}{hr} = 2.1\ min \cong 2 min$

PROJ. ID: 320-37
BY ELM 10/7/90 FSU 10/23/90

C. ESTIMATING T_c FROM LENGTHS AND SLOPES:



(a) Nomograph (SCS Guide)

L = length of longest watercourse in feet
H = difference in elevation in feet between outlet point and divide

(b.) Solution may be made by equation from California Culverts Practice, California Highways and Public Works, September 1942.

$$T = \left(\frac{11.9\,L^3}{H}\right)^{0.385}$$

$T = T_c$ in hours
L = length of longest watercourse in miles
H = elevation difference in feet

Example
L = 7,250 feet
H = 130 feet
then T_c = 0.57 hours

Lag, L, (SCS Guide) may be estimated directly for a basin by subdividing into tributary drainage subareas and using the relationship:

$$L = \frac{\Sigma a_x T_x}{A}\text{, where}$$

L = lag in hours
a_x = the x-th increment of area in sq. mi.
T_x = travel time in hours from center of a_x to main basin outlet
A = total area of basin, sq. mi.

Figure 30. Time of concentration estimates. (Sheet 2 of 2.) 288–D–2462.

Design of Small Dams, US Bureau of Reclamation, 1977

Storm Water Management

CHAPTER 9

MANAGEMENT–RURAL APPLICATIONS

Soil losses from rural environments have been considered to be of major agricultural significance. Regardless of the pollution control aspects, abatement of rural nonpoint source effects has been common. However, evaluations of water quality effects have focused more attention on the rural environments. The Universal Soil Loss Equation (USLE)[1] and Water Yield Model[2] are presented in this chapter with applications to illustrate storm water or nonpoint source water quantity and quality responses and management.

SEDIMENTATION AND EROSION

In general, cropland conditions that indicate a high sediment yield potential are those with long slopes farmed without terraces or runoff diversion, no cover between harvest and new crop growth, intense farming close to surface waters, formation of gullies and unstabilized roadways. Other rural areas can have high potential sediment problems and are generally associated with roadway surfaces, unstabilized streambanks, surface mining and unplanted areas.

An excellent U.S. Environmental Protection Agency (EPA) report[3] summarizes much of the materials and references on sediment studies. Of specific interest in this report is Table 3-1, entitled "Summary of Sediment Prediction Methods," (see Table 9.1), which indicates that EPA has identified three major methods for modeling sediment prediction: empirical, statistical and simulation. Of course, these methods are also chronological, with the empirical approach being perhaps the oldest. Each of these methods has various advantanges and diadvantages, which are further described in the references cited, as well as in the EPA report itself.

Although it appears that there are many possible sediment prediction methods that might be adapted in nonpoint pollution studies, many of the

Table 9.1 Summary of Sediment Prediction Methods[3]

	Process		
Prediction Method	Erosion	Transport	Deposition
Empirical			
Musgrave[4]	x	.	.
Universal Soil Loss Equation[1]	x	.	.
Einstein Bedload Function[5]	.	x	.
Colby Modified Einstein[5]	.	x	.
Toffaleti Total Load Method[5]	.	x	x
Lacey's Silt Theory[6]	.	x	x
Reservoir Surveys:	.	.	x
ARS			
Soil Conservation Service (SCS)	-		
Corp of Engineers			
Bureau of Reclamation (BR)			
U.S. Geological Survey (USGS)			
Statistical			
Flaxman[7]	.	.	x
Sediment Rating-Flow Duration:	.	.	x
U.S. Geological Survey			
Bureau of Reclamation			
Corp of Engineers			
W[illegible]ser's Deterministic Watershed model[8]	x	x	x
Simulation			
ARS Upland Erosion Model[9]	x	.	.
ARS USDAHL–73 Watershed Model[10]	x	x	x
ARS "ACTMA" Chemical Transport Model[11]	.	x	.
Negev's Watershed Model[12]	x	x	x
Stanford IV Model[13]	x	x	x
Hydrocomp Simulation[14]	x	x	x
Huff Hydrologic Transport Model[15]	.	x	.
Royal Institute (Sweden) Hydrologic Model[16]	x	x	x
Snyder's Parametric Hydrologic Model[17]	.	x'	x

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methods have limited applicability. Many simulation methods are proprietary and others are very complex and not readily amenable to quick studies and interpretation. Other statistical and simulation studies are limited in scope and, although very good for certain specific cases, are not readily adaptable to a variety of sediment loss situations.

Many pollution analysis programs such as STORM[18] use the Universal Soil Loss Equation empirical method,[1] and other reports and studies also indicate its general acceptability. The model is easy to use and interpret from simple hand calculations to more sophisticated computer programs.[19] Because of this simple adaptability as well as its readily understandable parameters, the next section will deal with this empirical model.

THE UNIVERSAL SOIL LOSS EQUATION (USLE)

The Universal Soil Loss Equation, an empirical method, was developed in the latter 1950s at the Runoff and Soil Loss Data Center of the Agricultural Research Service (ARS) at Purdue University. The equation was a modification of earlier empirical equations[4,20,21] which were found to be too localized for general use. Because of the more general applicability of the equation developed at Purdue it was called "universal." Although originally developed for soil conservation work in cropland areas, the equation has since been adapted and interpreted for other erosion loss problems. The original definitive publication on this equation was printed in 1965 by Wischmeier and Smith.

The USLE is the product of six factors:

$$A = (R)\ (K)\ (L)\ (S)\ (C)\ (P) \qquad (1)$$

where A = calculated soil loss in units of ton/ac/time period
R = rainfall factor/time period
K = soil-erodibility factor
L = slope-length factor
S = slope-gradient factor
C = cropping management factor
P = erosion-control practice factor

Sometimes Equation 1 is modified to include a sediment delivery factor which adjusts the estimated sediment loading based on deposition within the area. The sediment deposition is frequently estimated from direct field measurements.

The Rainfall Factor (R)

Early research on soil loss indicated that when all factors other than rainfall were held constant, then the soil loss was directly proportional to the product of the kinetic energy of the storm times its maximum 30-minute intensity. This factor has been called the Erosion Index (EI) factor. Data have been accumulated throughout the United States for suggested EI values to use, and several maps and charts give suggested data.[22] For an annual calculation, the rainfall factor (R) equals the number of erosion index units in a normal year's rain. Obviously, there will be variations from year to year as well as variations with the pattern of rainfall during a given year. Adjustments for these variations can be ıade when selecting or modifying the rainfall factor within the equation. xamples of such modifications will be given.

The isoerodent map as originally presented by Wischmeier and Smith[1] illustrated in Figure 9.1.[22] Depending on the variation of regional ıinfall, the R value used will accumulate in a different fashion in different ırts of a region. The suggested erosion-index distribution curves for six reas in Florida have been presented by Griffin.[23] Figure 9.2 shows ıe suggested erosion-index distribution curve for the north central region Florida. The curves plot the percentage rainfall factor accumulation as function of time. For example, in the north central region, 30% of the factor has accumulated by June 1 in an average year, while the remaining 70% will accumulate over the remainder of the year.

ıe Soil Erodibility Factor (K)

The soil erodibility factor (K) is an experimentally determined quantiıive factor. Many variables influence the erodibility of a soil, including particle-size distribution, organic content, structure, profile, etc. ıasured values on soils studied at erosion research stations have indicated K ran f from 0.03 to 0.69. Additional studies on various soil types ve res l in tables of suggested K values.[3] An indication of the ıeral ıitude of the soil-erodibility factor, K, for different soil tures and organic matter content are shown in Table 9.2 The nomoph method is shown in Figure 9.3. Judgment must be used when soils m to fit across several areas. When there is a variety of soils, individual al calculations must be made or an average K value must be selected. ecific area values of K are found in SCS publications and special plications.[19]

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Slope Length (L) and Slope Gradient (S) Factor

Obviously, the slope gradient and its length on a given plot or waterd will be a major factor in erosion potential, with steep slopes being re susceptible to soil loss. These two factors are usually combined in ıt is referred to as the Soil Loss Ratio, or the Topographic Factor, A recently suggested and used formula for the Topographic factor
4

$$LS = \left(\frac{\lambda}{72.6}\right)^m \left(\frac{430\ x^2 + 30\ x + 0.43}{6.57415}\right) \qquad (2)$$

e λ = field slope length, ft
m = 0.5 if slope equals 5% or greater
= 0.4 if slope equals 4%
= 0.3 if slope equals 3% or less
x = Sine of the slope angle

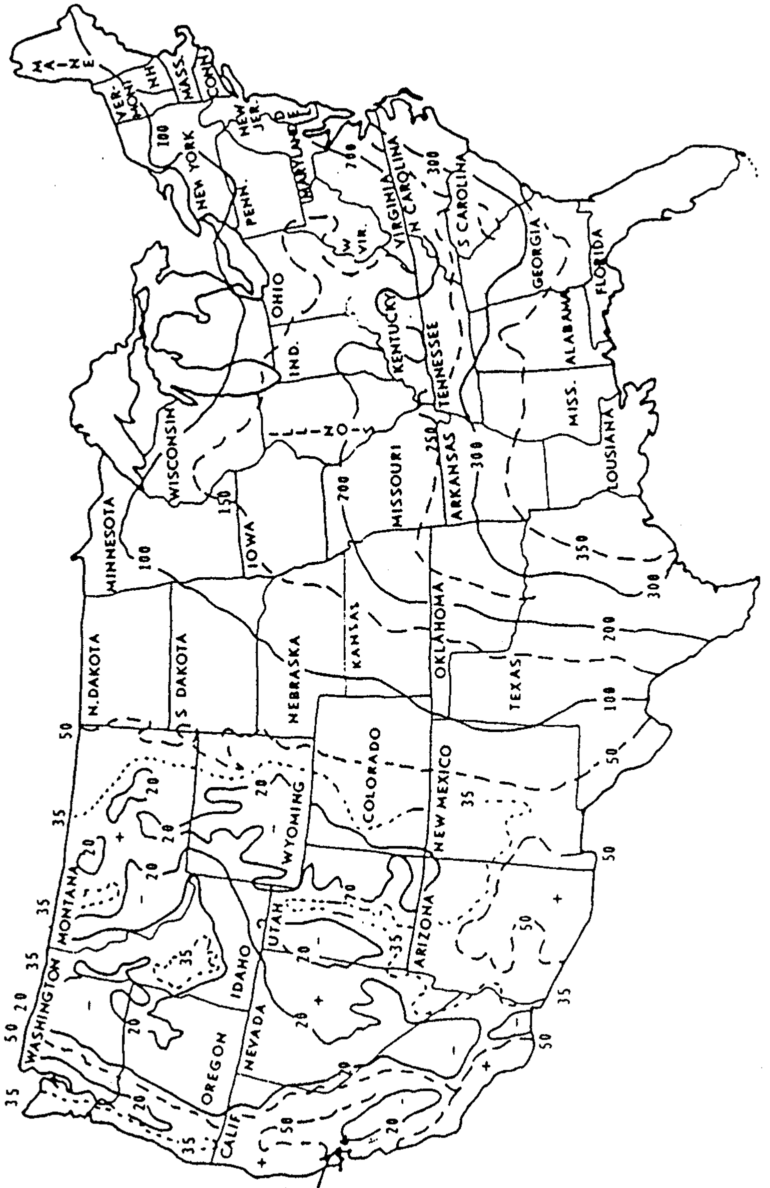

Figure 9.1 Average annual values of the rainfall erosivity factor, R.

FE 300

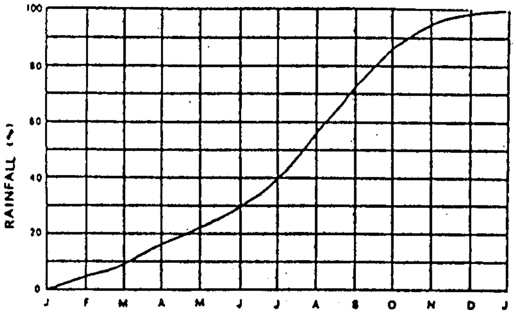

Figure 9.2 Rainfall distribution curve, north central Florida.

Table 9.2 Indications of the General Magnitude of the Soil-Erodibility Factor, K[3]

	Organic Matter Content		
Texture Class	<0.5% K	2% K	4% K
Sand	0.05	0.03	0.02
Fine Sand	0.16	0.14	0.10
Very [illegible] and	0.42	0.36	0.28
Loamy [illegible]	0.12	0.10	0.08
Loamy [illegible] Sand	0.24	0.20	0.16
Loamy Very Fine Sand	0.44	0.38	0.30
Sandy Loam	0.27	0.24	0.19
Fine Sandy Loam	0.35	0.30	0.24
Very Fine Sandy Loam	0.47	0.41	0.33
Loam	0.38	0.34	0.29
Silt Loam	0.48	0.42	0.33
Silt	0.60	0.52	0.42
Sandy Clay Loam	0.27	0.25	0.21
Clay Loam	0.28	0.25	0.21
Silty Clay Loam	0.37	$\boxed{0.32}$	0.26 ←
Sandy Clay	0.15	0.13	0.12
Silty Clay	0.25	0.23	0.19
Clay		0.13-0.29	

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The Topographic Factor can thus be calculated directly, presented in abular form, as in Table 9.3, or presented in graphic form, as in Figure).4.

The slope length requires some additional discussion. It is defined as he distance from the point of origin of overland flow either to (1) the

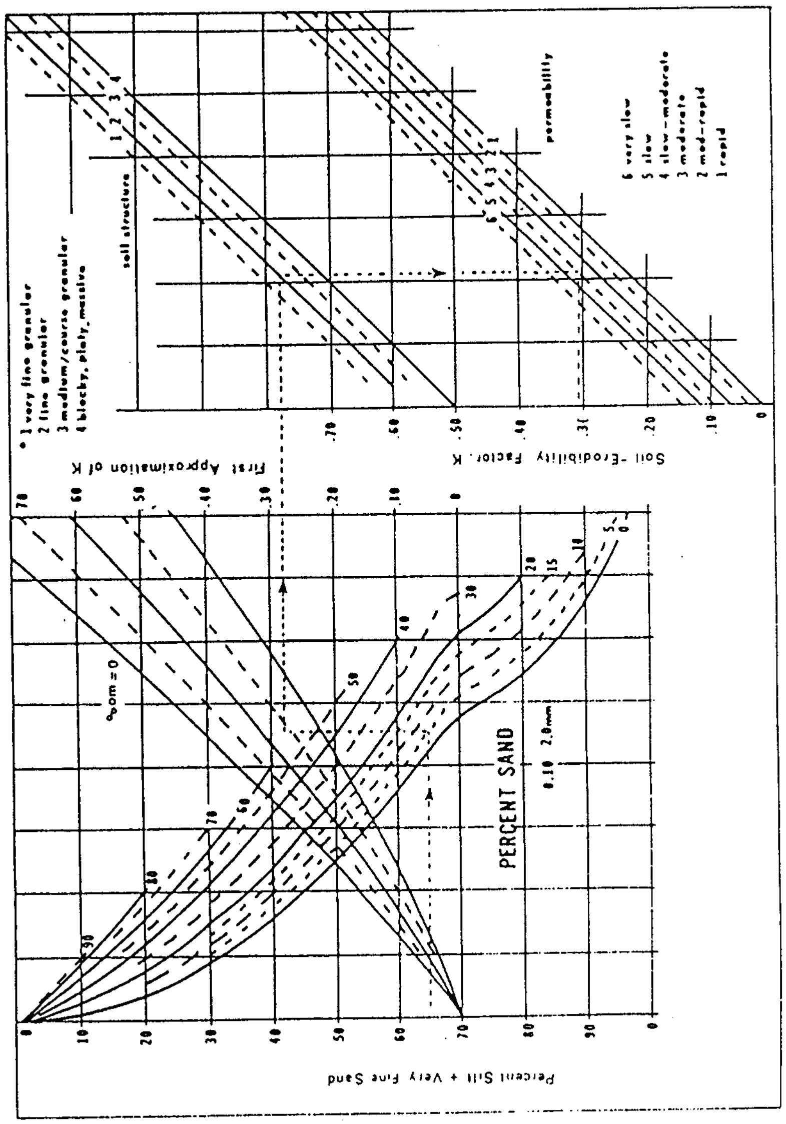


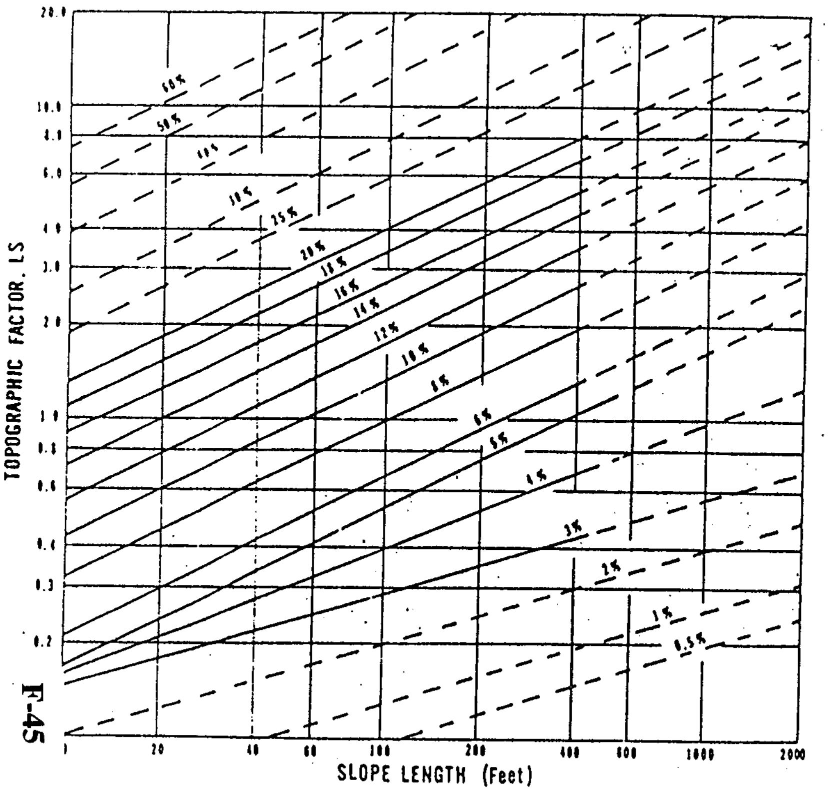
Figure 9.3 Nomograph for determining soil erodibility factor, K, for U.S. mainland soils.[3]

Table 9.3 Topographic Factor, LS, Slope-Effect Table

Percent Slope	Slope (Length) in Feet 60	80	100	110	120	130	140	150	160	180	200
0.20	0.07	0.07	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.10
0.30	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10
0.40	0.07	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11	0.11
0.50	0.08	0.09	0.09	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.12
1.00	0.11	0.12	0.12	0.13	0.13	0.14	0.14	0.14	0.14	0.15	0.15
2.00	0.17	0.18	0.20	0.20	0.21	0.21	0.22	0.22	0.23	0.24	0.24
3.00	0.24	0.26	0.28	0.29	0.30	0.31	0.31	0.32	0.33	0.34	0.35
4.00	0.32	0.36	0.40	0.41	0.43	0.44	0.45	0.47	0.48	0.50	0.52
5.00	0.42	0.47	0.53	0.56	0.58	0.61	0.63	0.65	0.67	0.71	0.75
6.00	0.52	0.60	0.67	0.70	0.73	0.76	0.79	0.82	0.85	0.90	0.95
8.00	0.76	0.88	0.99	1.04	1.08	1.13	1.17	1.21	1.25	1.33	1.40
10.00	1.06	1.22	1.36	1.43	1.50	1.56	1.62	1.67	1.73	1.83	1.93
12.00	1.39	1.61	1.80	1.89	1.97	2.05	2.13	2.21	2.28	2.42	2.55
14.00	1.77	2.05	2.29	2.40	2.51	2.61	2.71	2.81	2.90	3.07	3.24
16.00	2.19	2.53	2.83	2.97	3.11	3.23	3.35	3.47	3.59	3.80	4.01
18.00	2.66	3.07	3.43	3.60	3.76	3.91	4.06	4.20	4.34	4.60	4.85
20.00	3.16	3.64	4.07	4.27	4.46	4.65	4.82	4.99	5.16	5.47	5.76

HE BURN PITS

Percent Slope	Slope (Length) in Feet 300	400	500	600	700	800	900	1000	1100	1200	1300
0.20	0.11	0.12	0.13	0.14	0.14	0.15	0.15	0.16	0.16	0.17	0.17
0.30	0.12	0.13	0.14	0.15	0.15	0.16	0.16	0.17	0.18	0.18	0.18
0.40	0.12	0.14	0.15	0.15	0.16	0.17	0.18	0.18	0.19	0.19	0.20
0.50	0.13	0.14	0.16	0.16	0.17	0.18	0.19	0.19	0.20	0.20	0.21
1.00	0.17	0.19	0.20	0.22	0.23	0.24	0.25	0.25	0.26	0.27	0.27
2.00	0.27	0.30	0.32	0.34	0.36	0.37	0.38	0.40	0.41	0.42	0.43
3.00	0.39	0.43	0.46	0.49	0.51	0.53	0.55	0.57	0.59	0.60	0.62
4.00	0.62	0.69	0.76	0.81	0.87	0.91	0.96	1.00	1.04	1.08	1.11
5.00	0.92	1.07	1.19	1.31	1.41	1.51	1.60	1.69	1.77	1.85	1.93
6.00	1.16	1.34	1.50	1.64	1.78	1.90	2.01	2.12	2.23	2.33	2.42
8.00	1.71	1.98	2.21	2.42	2.62	2.80	2.97	3.13	3.29	3.43	3.57
10.00	2.37	2.73	3.06	3.35	3.62	3.87	4.10	4.33	4.54	4.74	4.93
12.00	3.12	3.60	4.03	4.42	4.77	5.10	5.41	5.70	5.98	6.25	6.50
14.00	3.97	4.58	5.13	5.62	6.07	6.49	6.88	7.25	7.61	7.95	8.27
16.00	4.91	5.67	6.34	6.95	7.51	8.02	8.51	8.97	9.41	9.83	10.23
18.00	5.94	6.86	7.68	8.41	9.08	9.71	10.31	10.86	11.39	11.89	12.38
20.00	7.06	8.15	9.12	9.99	10.79	11.53	12.23	12.90	13.53	14.13	14.70



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*The dashed lines represent estimates for slope dimensions beyond the range of lengths and steepnesses for which data are available. The curves were derived by the formula.

$$LS = \left(\frac{\lambda}{72.6}\right)^m \left(\frac{430x^2 + 30x + 0.43}{6.57415}\right)$$

where λ = field slope length in feet and $m = 0.5$ if $s = 5\%$ or greater, 0.4 if $s = 4\%$, and 0.3 if $s = 3\%$ or less; and $x = \sin\theta$. θ is the angle of slope in degrees.

Figure 9.4 Slope-effect chart (topographic factor, LS).

point where the slope decreases to the extent that deposition might occur, or (2) the point where runoff enters a well-defined channel. Whichever point is limiting becomes the basis for selecting the slope length. In many cases, of course, there is a variety of slope gradients and lengths. Under such conditions, the area must be broken up for separate calculations or some average value can be used.

Foster and Wischmeier[25] proposed an approach for determining the Topographic Factor when dealing with irregular slopes including the effects of concavity and convexity. The resulting modifications can cause variations of from 30-40% in the predicted soil loss. For his gross assessment method, True[26] uses a simplified Topographic Factor equation for all slopes and slope lengths:

$$LS = (L/75)^{0.6}\ (S/9)^{1.4} \tag{3}$$

where L is the slope length in feet and S is the slope in percent. The use of Equation 3 can also cause variations of from 30-40% or more in the soil loss prediction, when compared to Equation 1 and used for shallow slopes.

Depending on the sophistication of the desired calculations it is clear that there are several approaches in using the Topographic Factor. The analyst must use judgment to determine how much time and effort must be expended on this particular factor, especially in light of the effects of the other factors in the equation.

The Cropping Management Factor (C)

The Cropping Management Factor, C, also called the Cover Factor, is the ratio of the soil loss using certain cover and cropping conditions compared to the corresponding loss assuming continuous fallow. Obviously, if cropping practice varies annually, the C factor will also. Wischmeier and Smith propose a very complicated technique for determining the C factor for a variety of agricultural conditions. Griffin[23] gives suggested C factors for a variety of construction site conditions. It can be seen that this factor can vary through several orders of magnitude, from 0.01 for sodding and permanent seeding to 1.0 for fallow ground, as shown in Table 9.4.

The 1973 Council on Environmental Quality (CEQ) report to the President recommended typical cropping management factors for the following general land use categories:

Land Use	*C Factor*
Crop Land	0.08
Pasture Land	0.01
Forest Land	0.005
Urban Land	0.01
Other	1.0

Recent SCS suggestions for the Cover Factor for pasture, range and woodland are documented in the literature.[24]

Obviously, from the range of C factors encountered, the analyst must also use considerable judgment in assigning this variable

Table 9.4 Cover Index Factor, C—Construction Sites

		Factor C
None (fallow ground)		1.0
Temporary Seedings (90% stand)–after 60 days		
Ryegrass (perennial type)		0.05
Ryegrass (annulus)		0.1
Small Grain		0.05
Millet or Sudan Grass		0.05
Permanent Seedings (90% stand).		
First 60 days		0.40
60-365 days		0.05
After 365 days		0.01
Sod (laid immediately)		0.01
Mulch		
Hay rate of application, ton/ac		
	0.50	0.25
	1.00	0.13
	1.50	0.07
	2.00	0.02
Small Grain Straw	2.00	0.02
Wood Chips	6.00	0.06
Wood Cellulose	1.75	0.1
Fiberglass	0.50	0.05
sphalt Emulsion (1250 gal/ac)		0.02

he Erosion-Control Practice Factor (P)

The Erosion-Control Practice Factor, P, enables the analyst to account or various mechanical erosion control practices such as contouring, teracing and strip-cropping. Recommended P factors, as a function of land lope, are given in Table 9.5.

It is possible for the P factor to be greater than 1.0 if certain practices ctually aid erosion. In conjunction with the 1973 Council of Environental Quality report, True[26] recommends the following P factors for e broad land use designations previously described under the C factor:

Land Use	*P Factor*
Crop Land	0.50 >btwn the two
Pasture Land	1.0
Forest Land	1.0
Urban Land	1.0
Other	1.3

Table 9.5 Erosion-Control Practice Factors, P

Land Slope (%)	P Factor Strip Cropping or Ridge Planting	Terracing	Contour Strip Cropping[a]		
			R-W	R-R-M-M	R-S
1.1-2	0.30	0.12	0.52	0.30	0.60
2.1-7	0.25	0.10	0.44	0.25	0.50
7.1-12	0.30	0.12	0.52	0.30	0.60
12.1-18	0.40	0.16	0.70	0.40	0.80
18.1-24	0.45	0.18	0.90	0.45	0.90

[a] R = row crop; W = fall-seeded grain; S = spring-seeded grain; and M = meadow.

As with the Cover Factor, C, considerable judgment must be used in applying the Erosion Control Practice Factor, P.

EXAMPLE 9.1 As an example of the use of the USLE, an Alabama country club watershed has the following parameters:

Area = 240 ac
Soil type = sand, rapid permeability (K = 0.17)
Average slope length = 600 ft
Average slope gradient = 1.0% (from Table 9.5, LS = 0.22)
Predominant land use = cropland (groves); (C = 0.08, P = 0.5)

Then, the USLE would give the following hand calculations:

$$\begin{aligned} A &= (R)\ (K)\ (L)\ (S)\ (C)\ (P) \\ &= (350)\ (0.17)\ (0.22)\ (0.08)\ (0.5) \\ &= 0.524 \text{ ton/ac, annual basis} \\ &= 126 \text{ tons, annual basis} \end{aligned}$$

To convert this into cubic yards , the SCS uses the factors shown in Table 9.6. Thus, for a sand:

$$\text{Volume} = 126.0 \text{ ton} \times 0.67 = 84 \text{ yd}^3$$

EXAMPLE 9.2 An improvement on this single-area hand calculation would be : break up the watershed into two areas. The following might be a reasonable breakdown:

Pasture Lands (fairways, etc.)	*Crop Lands (groves, etc.)*
30 ac	210 ac
K = 0.17	K = 0.17
C = 0.01	C = 0.08
P = 1.0	P = 0.5

Table 9.6 Approximate Weights of Soils (lb/ft^3) and Factors for Converting Soil Losses (air-dry) from Tons to Cubic Yards

	Volume Weight (lb/ft^3)	Tons to Cubic Yards
Sands and Loamy Sands	110	0.67
Sandy Loams	105	0.71
Fine Sandy Loam	100	0.74
Loam	90	0.82
Silty Loam	85	0.87
Silty Clay Loam	80	0.93
Clay Loam	75	0.99
Silty, Sandy Clay and Clay	70	1.06
Aerated Sediment	80[a]	0.93
Saturated Sediment	60[a]	1.24

[a] These are the approximate aerated and saturated weights to be used at damage sites (streams or reservoirs).

Then the total annual yield from this watershed (assuming same slope ata) ld be:

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Annual Soil Loss in Tons = (350) (0.17) (0.22) (0.01) (1.0) x 30 ac + (350) (0.17) (0.22) (0.08) (0.5) x 210 ac
= 4.6 + 110.0 = 114.6 tons (annual basis).

This should be compared with 126 tons from the previous example.

To make further modifications and include other variables would simply quire an extension of the above hand calculations with careful bookeeping to ensure that all areas are properly categorized and calculated.

onclusions on USLE

One can be as sophisticated as one desires with the USLE, even with nd calculations. If a watershed has a great variety of slope gradients d lengths, soil types, land uses, etc., then the entire watershed could divided into smaller areas. Each area could be calculated individually d then the sum of the results used for the entire watershed

It is obvious from the above examples that using the USLE requires nsiderable judgment, and the numbers resulting from any calculations cover a broad spectrum. For considering the various factors involved soil loss, however, the USLE can provide broad numerical guidelines, ich can assist planners and analysts in formulating erosion control and er practices to cut down on soil loss.

The USLE does not include any factors to account for rill or gully erosion. Areas with considerable gully erosion must use other predictive methods to complement or supplement the results of USLE calculations.[3]

WATER YIELD MODEL

The Water Yield model uses the SCS cover complex method (curve number, CN) with modifications for water storage.[2] Usually, two Water Yield models will be used—the Calibration model and Record Extending model. The Calibration model utilizes daily rainfall, monthly flow data and lake evaporation (LE) and predicts the long-term CN, soil moisture depletion coefficient (B). The Record Extender model uses daily rainfall, starting CN, long-term CN, B and lake evaporation to predict daily runoff from the watershed. The program was modified by Smoot[27] to include water quality.

In reality, the CN varies continuously with soil moisture. Runoff prediction accuracy can be improved by using a soil moisture accounting procedure to estimate the curve number for each storm. The soil moisture index, SM, is related to the potential abstraction (S′) by:

$$SM = V \cdot S' \qquad (4)$$

where V = maximum soil storage equal to 20 in. or 50.8 cm

The soil moisture maximum value was picked because it provides ample storage to allow a wide range of curve numbers (33 1/3-100) and yet is small enough to allow daily rainfall to influence SM properly. Substituting for S′, SM becomes:

$$SM = V \cdot S' = V \cdot \frac{b}{CN} + c \qquad (5)$$

where b = 1000 in. (English) or 2540 cm (metric)
c = 10 in. or 25.4 cm

and SM = 30-1000/CN (English)

or SM = 76.2-2540/CN (Metric)

Soil moisture is usually depleted continuously between storms by evapotranspiration, deep seepage and other net changes. Depletion is greater when soil moisture and evaporation are high, and most rapid immediately after a storm (high SM). Thus, a depletion relationship is assumed as a second-order equation or:

$$\frac{d(SM)}{dt} = -B \times LE \times SM^2 \qquad (6)$$

where t = time
B = depletion coefficient
LE = lake evaporation

DESIGN FLOW, RATIONAL METHOD

RUNOFF FROM HE BURN PIT DRAINAGE

I, CALCULATION OF DESIGN RAINFALL, I (cont)

$T_c = 2$ min for all overland flow

DESIGN precipitation (PMP)

T_c (minimum provided on tables) = 5 m ⟹ PMP = 0.89"

$$I = \frac{0.89''}{5\,min} \times \left(\frac{60}{5}\right) = 10.7''/hr \text{ (conservative)}$$

AREA

A = Area of watershed as determined from topographic base map with planimeter

$$A = X \text{: planimeter units (p.u.)} \times \left[0.0158 \text{ correction factor} \times \frac{200^2\,ft^2}{in^2} \times \frac{acre}{43{,}560\,ft^2}\right]$$

$$A_{TOTAL} = 175\,pu \times 0.0145\,\frac{acre}{pu} = 2.54\,acres$$

$$A_{HE\,BURN\,PITS} = 57\,pu \times 0.0145 = 0.83\,acres$$

$$A_{HILLSIDE} = 118 \times 0.0145 = 1.71\,acres$$

Proj 10-300-57
By ELM 10/7/90 FEL 10/23/

DESIGN FLOW, RATIONAL METHOD

RUNOFF FROM HE BURN PIT DRAINAGE

$$Q_{TOTAL} = C\,I\,A = 0.6 \times 10.7\,\frac{in}{hr} \times 2.54 \text{ acres} = 16.3 \text{ cfs}$$

$$Q_{HE\,BURN\,PITS} = 0.6 \times 10.7\,\frac{in}{hr} \times 0.83 \text{ ac} = 5.3 \text{ cfs}$$

$$Q_{HILLSIDE} = 0.6 \times 10.7\,\frac{in}{hr} \times 1.71 \text{ ac} = 11.0 \text{ cfs}$$

$$\text{TOTAL} : \overline{16.3 \text{ cfs}}$$

Assume Design Flow of 16.3 cfs.

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PORTLAND CONCRETE DITCHES
DESIGN PARAMETERS

OBJECTIVE: TO SET DESIGN CONDITIONS FOR SIZING A PCC-LINED CULVERT TO COLLECT AND DIRECT RUNOFF AROUND HE BURN PITS.

DEFINITIONS: Q_{PMP} = DESIGN FLOW RATE (cfs)

S_0 = SLOPE OF BOTTOM CHANNEL FROM TOPO MAPS.

ASSUMPTIONS: CHANNELS ARE PRIMARILY STRAIGHT
EARTHWORK GRADING WILL BE MINIMAL

METHOD: COMPARE TOPO MAP DATA TO PROPOSED DITCH LOCATIONS TO GET SLOPE (S_0) PARAMETERS

DATA: Q_{PMP} PREVIOUS CALCS

Q_{TOTAL} = 16.3 cfs

$Q_{HE\ B.P.}$ = 5.3 cfs

$Q_{HILLSIDE}$ = 11.0 cfs

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PORTLAND CONCRETE DITCHES

DESIGN FLOW CALCULATIONS

OBJECTIVE: Determine Flow Depth in PCC Channel w/ Manning's Eq.

DEFINITIONS:
Q = Design flow rate cfs
n = Manning's coefficient = 0.013 (smooth concrete culverts)
d = flow depth, ft
g = gravitational acceleration = 32.2 ft/s^2
V = velocity of flow (ft/s)
r = radius of channel bend
z = Channel side slope inclination, $\frac{z}{1}$
S_v = superelevation of water surface in channel bend.
b = Channel bottom width (ft)
e = $d \times z$ S_0 = Slope

ASSUMPTIONS:
Slope of channel bottom = slope of EGL
Manning's Eq. is appropriate for flow
Flow velocity represents average.

METHOD: Manning's Equation for normal Flow Depth

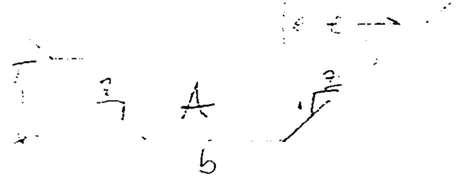
$$V = \frac{1.49}{n} R^{2/3} S_0^{1/2}$$

S_0 = hydraulic gradient ft/ft
R = hydraulic radius, ft = $\frac{\text{Area}}{\text{wetted Perimeter}}$

$$A = \frac{1}{2}(b + 2e + b) \times d$$

$$wp = b + 2(d^2 + e^2)^{1/2}$$

$$R = \frac{A}{wp}$$



BY ELM FEC 10/12/10

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DESIGN FLOW CALCS cont.

CHANNEL ALONG HILLSIDE ABOVE CAP (SEGMENT 1)

GIVEN: $Q_{pmp} = 16.3$ cfs $S_o = 0.05$ $n = 0.013$

ASSUME $b = 0.75'$ $e = 0.80'$ $d = 0.8'$ $Z = 1.0$

$\therefore$ $R = 0.408$ $A = 1.24\,ft^2$ $wp = 3.01'$

$$V = \frac{1.49}{0.013} \times 0.408^{.67} \times 0.05^{0.5} = 14.1\,fps$$

$$Q = 14.1\,fps \times 1.24\,ft^2 = 17.5\,fps > 16.3\,cfs$$ [illegible]

CHECK SUPERELEVATION (S_u)

$$S_u = \frac{1.15\,V^2\,(b + 2zd)}{2gr}$$

$$S_u = \frac{1.15\,(14.1)^2\,(0.75 + 2(1)(0.8))}{2\,(32.2)\,60'} = 0.071'$$

CONSTRUCT TRENCH DEPTH @ 1.0' with Z = 1:1

Therefore, at maximum depth of 1.0 ft.

$b = 0.75'$; $e = 1.0'$; $d = 1.0'$; $Z = 1.0$

$R = 0.489$ $A = 1.75$ $wp = 3.58$

$$V = \frac{1.49}{0.013}\,0.489^{.67}\,0.05^{.5} = 15.9\,fps$$

$$Q = 15.9\,fps \times 1.75 = 27.8\,cfs$$

Fec 10/23/90

SEGMENT 2

GIVEN: $Q_{PMP} = 16.3$ cfs $S_0 = 0.11$ $n = 0.013$

$b = 0.75'$ $d = ?$

$$Q = \frac{1.49}{0.013} A R_h^{.67} 0.11^{.5} = 16.3 \text{ cfs}$$

$$A R_h^{.67} = \frac{A^{1.67}}{wp^{.67}} = 0.429$$

By trial & error,

	d	A	wp	$AR_h^{.67}$ = 0.429
	0.5	0.625	2.165	0.272
	0.6	0.81	2.45	0.386
	0.7	1.02	2.73	0.527
7.5"	0.625	0.859	2.52	0.418
8.0"	0.67	0.94	2.64	0.471

> MAX. DEPTH OF FLOW BTWN 7½"–8"

$$\therefore VEL = \frac{16.3}{0.9} = 18 \text{fps}$$

SEGMENT 3

GIVEN: $Q_{PMP} = 16.3$ $S_0 = .25$ $n = 0.013$

$b = 0.75'$ $d = ?$

$$Q = \frac{1.49}{0.013} A R_h^{.67} 0.25^{.5} \therefore AR_h^{.67} = \frac{16.3}{57.31} = 0.284$$

By Trial + Error,

d	A	wp	$AR_h^{.67}$ = 0.284
0.5	0.625	2.165	0.272
0.592	0.700	2.25	0.317

> MAX DEPTH OF FLOW BTWN 6"–6½"

$\therefore$ VEL = 16.3/.65 = 25 fps [illegible]

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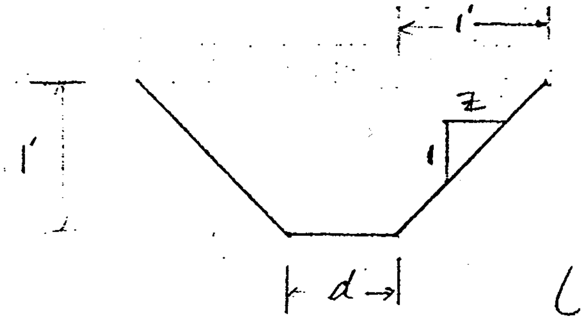
DESIGN FLOW CALCULATIONS, cont.

MAXIMUM DEPTHS OCCUR AT MINIMUM SLOPES

	So	Qpmp, cfs	Depth ft	Approx Velocity fps
Segment 1	0.05	16.3	0.8	13
Segment 2	0.11	16.3	0.66	18
Segment 3	0.25	16.3	0.54	25

PROVIDE 1 FOOT DEEP, CONCRETE TRAPEZOIDAL CHANNEL



d = 1'

z = 1'

Lined depth = 0.75'

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OPEN CULVERT DESIGN

OBJECTIVE: Specify long life Portland Cement Concrete Lining

DEFINITION: t = lining thickness (in.)

d = depth to centroid of reinforcing steel from compression face of concrete

As = Area of reinforcing steel

Cl = Clearance from outside surface of concrete to side (edge) of reinforcement steel

ACI + UBC codes values are minimum acceptable

ACI + UBC codes are rounded up.

$$t_{Min} = Cl_{SOIL\ to\ REBAR} + (2 \times \text{Rebar dia.}) + Cl_{\text{Rebar to Channel Lining}}$$

$$t_{Min} = 3.0'' + (2 \times 0.500'') + 3.0'' = 7.0''$$

$$A_{s_{Min}} = 0.002 \times \text{gross area}$$

$$= 0.002 \times (7'' \times 24'') = 0.336\ in^2$$

$$A_s = 0.20\ in^2 \times 3 = 0.6\ in^2$$

$$A_s > A_{s_{Min}} \quad \text{check.}$$

Along length of channel, place rebar every 14 inches (#4 Rebar = 0.20 in²):

$$L = \frac{0.20}{0.002} \cdot \frac{1}{7''} = 14''$$

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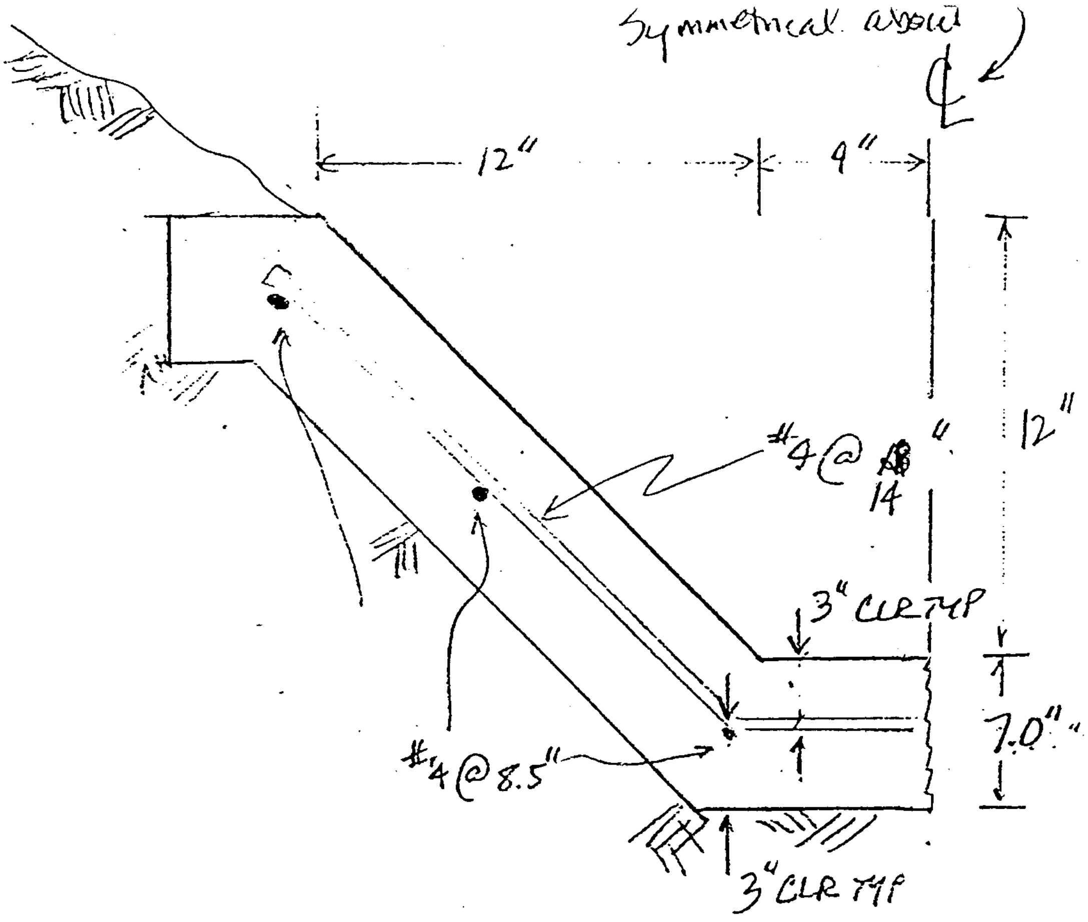

Construction Drawing 6

1 Concrete Detail

Typical Half Section

HE BURN PIT CLOSURE

SITE 300 LLNL

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3.) BUREAU OF RECLAMATION (1977), DESIGN OF SMALL DAMS.

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Supplement F.III.

Compaction Equipment Selection

...BLE 5
Compaction Equipment and Methods

Equipment Type	Applicability	Requirements for Compaction of 95 to 100 Percent Standard Proctor Maximum Density			Possible Variations in Equipment
		Compacted Lift Thickness, in.	Passes or Coverages	Dimensions and Weight of Equipment	
Sheepsfoot Rollers	For fine-grained soils or dirty coarse-grained soils with more than 20 percent passing No. 200 sieve. Not suitable for clean coarse-grained soils. Particularly appropriate for compaction of impervious zone for earth dam or linings where bonding of lifts is important.	6	4 to 6 passes for fine-grained soil. 6 to 8 passes for coarse-grained soil.	Soil Type — Foot Contact Area, sq. ft. — Foot Contact Pressures psi Fine-grained soil PI>30 — 5 to 12 — 250 to 500 Fine-grained soil PI<30 — 7 to 14 — 200 to 400 Coarse-grained soil — 10 to 14 — 150 to 250 Efficient compaction of soils wet of optimum requires less contact pressure than the same soils at lower moisture contents.	For earth dam, highway and airfield work, articulated, self propelled rollers are commonly used. For smaller projects, towed 40 to 60 inch drums are used. Foot contact pressure should be regulated so as to avoid shearing the soil on the third or fourth pass.
Rubber Tire Roller	For clean, coarse-grained soils with 4 to 8 percent passing the No. 200 sieve.	10	3 to 5 coverages	Tire inflation pressures of 35 to 130 psi for clean granular material or base course and subgrade compaction. Wheel load 18,000 to 25,000 lbs.	Wide variety of rubber tire compaction equipment is available. For cohesive soils, light-wheel loads, such as provided by wobble-wheel equipment, may be substituted for heavy-wheel load if lift thickness is decreased. For granular soils, large-size tires are desirable to avoid shear and rutting.
Do.......	For fine-grained soils or well graded, dirty coarse-grained soils with more than 8 percent passing the No. 200 sieve.	6 to 8	4 to 6 coverages	Tire inflation pressures in excess of 65 psi, for fine-grained soils of high plasticity. For uniform clean sands or silty fine sands, use large size tires with pressures of 40 to 50 psi.	
Smooth Wheel Rollers	Appropriate for subgrade or base course compaction of well-graded sand-gravel mixtures.	8 to 12	4 coverages	Tandem type rollers for base course or subgrade compaction 10 to 15 ton weight, 300 to 500 lbs per lineal in. of width of rear roller.	3-wheel rollers obtainable in wide range of sizes. 2-wheel tandem rollers are availabe in the range of 1 to 20 ton weight. 3-Axle tandem rollers are generally used in the range of 10 to 20 tons weight. Very heavy rollers are used for proof rolling of subgrade or base course.
Do....	May be used for fine-grained soils other than in earth dams. Not suitable for clean well-graded sands or silty uniform sands.	6 to 8	6 coverages	3-wheel roller for compaction of fine-grained soil; weights from 5 to 6 tons for materials of low plasticity to 10 tons for materials of high plasticity.	

Source: NAVFAC DM 7.2. May 1982

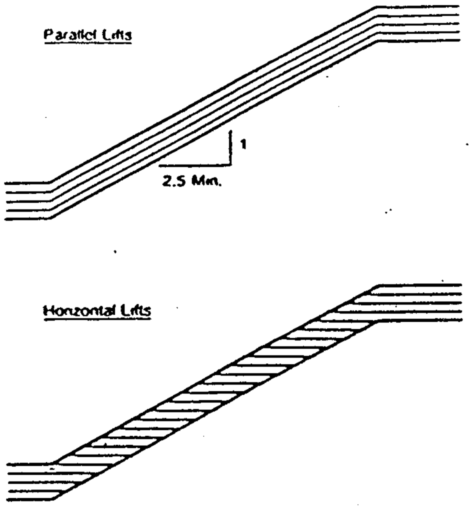


Figure 6-8. Liner construction on side slopes with horizontal and parallel lifts.

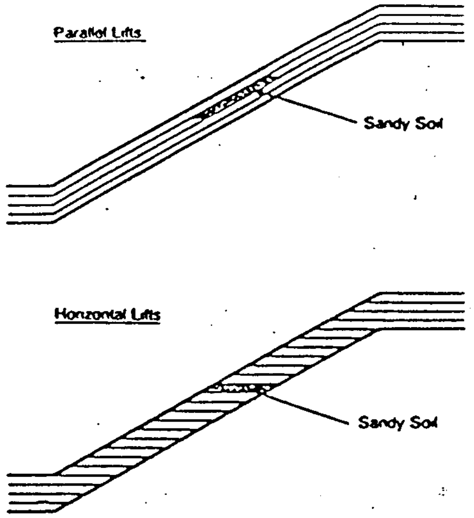


Figure 6-9. Effect of sandy soil zone on liners with parallel and horizontal lifts.

slope angle of about 22 degrees), because the compaction equipment cannot operate on them.

On surfaces without steep slopes, soil liners with parallel lifts are less sensitive to some of the defects that might occur during construction than those built with horizontal lifts. Figure 6-9 shows a liner containing a quantity of sandy material. With parallel lifts, the sandy zone is surrounded by zones of good soil, and so has little influence. But with horizontal lifts, a window through the soil liner could allow greater permeability to waste leachate if it were to occur on the bottom in a sump area.

Compaction Equipment

In addition to increasing bonding between lifts (as discussed in the previous section), the equipment used to compact soil liners should maximize compactive energy and the remolding capability of the soil. The type of roller, weight of the roller, and number of passes the equipment makes over the surface of the soil are all important factors. The heaviest rollers available weigh between 50,000 and 70,000 pounds. The Caterpillar 825 is an example of one of the heaviest, weighing more than 50,000 pounds and having long, penetrating feet. A medium weight roller weighs between 30,000 and 50,000 pounds and a relatively light roller weighs 15,000 to 30,000 pounds.

The best way to compare one roller to another is to examine weight per linear foot along the drum surface. A very lightweight roller will typically weigh about 500 pounds per linear foot along the drum surfaces, while a very heavy roller weighs 3,000 to 5,000 pounds per linear foot.

Vibratory rollers, weighing typically 20,000 to 30,000 pounds static weight may not be effective for clay compaction. A piece of vibration equipment inside the drum gives the vibratory roller its name. The drums of static rollers are filled with liquid, making them very heavy. The vibratory equipment inside the drum of the vibratory roller, however, prevents it from being filled with water, so the total weight is in the drum itself. This kind of roller works well for compacting granular base materials beneath pavements, so contractors frequently have them available. However, there is no evidence that the high frequency of vibration is effective in compacting clay.

Vibratory rollers are not good rollers for compacting clay liner materials for several reasons. First, the padfoot (only about 3 inches long) does not fully penetrate the soil. Second, the area of the foot is fairly large. Because the weight is spread over a large area, the stresses are smaller and the soil is not compacted as effectively. The smaller the area of the foot, the more effective in remolding the soil clods. Third, the roller is relatively lightweight, weighing

Source U.S. EPA, "How to Meet Requirements for Hazardous Waste Landfill Design, Construction and Closure", 1990 Noyes Data Corp.

only 20,000 to 30,000 pounds. In addition, approximately half the rollers' weight goes to the rear axle and the rubber tires, leaving only about 15,000 pounds or less to be delivered to the drum.

The feet of a classic sheepsfoot roller, in contrast to those of the vibratory roller, are about 9 inches long. The area of the foot is relatively small so that the compact stress on the tip typically ranges from 200 to 700 pounds per square inch. The drum normally is filled with liquid so that great weights are achieved directly on the drum. Manufacturers make very few sheepsfoot rollers now, despite the fact that they are the most effective roller for clay compaction. The Caterpillar 815 and 825 are two of the few sheepsfoot rollers currently being produced.

The Construction Process

Table 6-2 outlines the major steps in the construction process for clay liners. First, a source of soil to be used in constructing the liner must be found. Then the soil is excavated at this location from a pit called a "borrow pit." (Excavated soil is referred to as "borrow soil.") Digging tests pits in the borrow area helps determine the stratification of the soil before beginning excavation of the borrow pit itself.

Table 6-2. Steps in the Construction Process

1. Location of Borrow Source
   - Boreholes, Test Pits
   - Laboratory Tests
2. Excavation of Borrow Soil
3. Preliminary Moisture Adjustment; Amendments; Pulverization
4. Stockpile; Hydration; Other
5. Transport to Construction Area; Surface Preparation
6. Spreading in Lifts; Breakdown of Clods
7. Final Moisture Adjustment; Mixing; Hydration
8. Compaction; Smoothing of Surface
9. Construction Quality Assurance Testing
10. Further Compaction, If Necessary

The borrow soil is mixed and blended as it is excavated to produce as homogeneous a soil as possible. Scrapers are useful for excavating soils from borrow areas, because the soil is mixed up in the scraper pan by the action of the scraper. The soil also can be sieved and processed through a rock crusher to grind down hard clods. Cutting across zones of horizontal stratification also will help mix up the soil as it is excavated. Using some of these methods, the excavation process can be designed to maximize soil mixing without significantly increasing excavation costs.

The next step is to moisten or dry the soil as needed. If the required change in water content is only 1 to 2 percent, the adjustment in moisture content can be made after the soil is put in place and before it is compacted. However, if a substantial change in soil moisture content is necessary, it should be performed slowly so moistening occurs uniformly throughout the soil. To change the soil moisture content, the soil is spread evenly in a layer, moistened, and then covered for several days, if possible, while the moisture softens the soil clods. A disc or a rototiller passed through the soil periodically speeds up the process.

If soil moisture content is too high, the soil should be spread in lifts and allowed to dry. Mixing the soil during the drying process will prevent a dry crust of soil from forming on the top with wet soil underneath.

When the moisture adjustments have been made, the soil is transported to the construction area. Then the soil is spread in lifts by bulldozer or scraper, and a disc or rototiller is used to break down soil clods further. A pulvermixer, a piece of equipment widely used for reclaiming asphaltic concrete pavement, also works well. These machines can pulverize and mix a lift of soil as much as 24 inches deep.

Once the soil is in place and prior to compaction, minor adjustments in moisture content again can be made. No large changes in water content should be made at this time, however.

In the next step, the soil is compacted. Afterwards, the surface of the soil may be smoothed by a smooth steel drum roller before the construction quality control inspector performs the moisture density test. If the test indicates that the soil has been compacted adequately, the next lift is placed on top of it. If the compaction has not been performed properly, the soil is either compacted further or that section of the liner is dug up and replaced.

Soil-Bentonite Liners

When there is not enough clay available at a site to construct a soil liner, the clay can be mixed with bentonite. The amount of bentonite needed should be determined in the laboratory and then adjusted to account for any irregularities occurring during construction. Dry bentonite is mixed with the soil first, and water is added only after the mixing process is complete.

The bentonite can be mixed using a pugmill or by spreading the soil in lifts and placing the bentonite over the surface. Passing a heavy-duty pulvermixer repeatedly through the soil in both directions mixes the soil with the bentonite. After the bentonite and clay are mixed, water is added in small amounts, with the soil mixed well after each addition. When the appropriate moisture content is reached, the clay-bentonite soil is compacted.

Appendix G

Appendix G.

Sensitivity

Sensitivity

As part of the modeling effort for the HE Open Burn Treatment area, we examined the sensitivity of predicted maximum TCE concentrations reaching the Tnbs_1 regional aquifer to the decay half-life ($t_{1/2}$), the volumetric water content (θ), and the recharge rate (Q).

G.1 Decay Half-Life ($t_{1/2}$)

We assumed the TCE decay half-life to be 50 years. With this value, the maximum predicted concentration to reach the regional aquifer is 6.6×10^{-20} µg/L (ppb). This concentration is so low that it is essentially zero because the level of accuracy for the program input is two significant figures. Because the model is very sensitive to the decay half-life, to increase it would yield a much smaller number that would also essentially be zero. Decreasing the half-life to zero also changes values drastically, but in a direction of higher, significant values. The maximum predicted concentration to reach the regional aquifer using a zero decay half-life is 3.4 µg/L (ppb) in 1295 years.

G.2 Recharge Rate (Q)

The recharge rate is also a very sensitive parameter. Assuming a recharge rate of 10% of precipitation produced a maximum predicted concentration value of 6.6×10^{-20} µg/L (ppb). Using a recharge rate of 50% and 5% of precipitation yields maximum predicted concentrations of 6.2×10^{-8} and 1.6×10^{-20} µg/L (ppb), respectively, reaching the regional aquifer in 100 and 105 years, respectively.

G.3 Volumetric Water Content (θ)

The volumetric water content is the most sensitive parameter. Assuming a volumetric water content of 0.17 resulted in a maximum concentration of 6.6×10^{-20} µg/L (ppb) reaching the regional aquifer. Using 0.13 and 0.20 for the volumetric water content yields maximum predicted concentrations of 2.0×10^{-9} and 0.0 µg/L (ppb) at 95 years and at any year, respectively, to reach the regional aquifer. Because the model ignores changes in hydraulic conductivity, it overestimates the apparent sensitivity of TCE concentrations to the water-filled porosity.

Appendix H

Appendix H.

Required Analyses and Monitoring Data

Table H-1. Historic ground water data.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
EPA Method 601								
1,1,1-Trichloroethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.5		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.5		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
1,1,2,2-Tetrachloroethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.5		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.5		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
1,1,2-Trichloroethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.6		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.6		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
1,1-Dichloroethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.4		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.4		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
1,1-Dichloroethene(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.2		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.2		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
1,2-Dichlorobenzene(μg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<4		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<4		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
1,2-Dichloroethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.3		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.3		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
1,2-Dichloroethene (total)(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.4		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.4		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
1,2-Dichloropropane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.5		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.5		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
1,3-Dichlorobenzene(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<2		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<2		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
1,4-Dichlorobenzene(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<4		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<4		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
2-Chloroethylvinylether(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<1		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<1		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Bromodichloromethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.7		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.7		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Bromoform(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.7		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.7		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Bromomethane(μg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.7		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.7		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Carbon tetrachloride(μg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.6		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.6		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Chlorobenzene(μg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.7		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.7		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Chloroethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.5		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.5		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Chloroform(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.5		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.5		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Chloromethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.6		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.6		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
cis-1,2-Dichloroethene(µg/L)					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.4		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.4		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
							06/20/96	<0.5
cis-1,3-Dichloropropene(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.5		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.5		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Dibromochloromethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.6		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.6		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Dichlorodifluoromethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	0.7		
					08/16/91	<1		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<1		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Freon 113(µg/L)					04/22/87	1.2		
					03/14/88	0.9		
					06/27/88	1.2		
					10/25/88	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.6		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.6		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Methylene chloride(μg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<2		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					06/30/92	<2		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Tetrachloroethene(μg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.5		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.5		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
trans-1,2-Dichloroethene(μg/L)					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.4		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.4		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
							06/20/96	<0.5
trans-1,3-Dichloropropene(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.6		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.6		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
							06/20/96	<0.5
Trichloroethene(µg/L)					04/22/87	5.2		
					03/14/88	5.4		
					06/27/88	2.1		
					10/25/88	4.5		
					02/10/89	<0.5		
					04/12/89	3.4		
					07/13/89	5.8		
					10/12/89	4.9		
					01/18/90	4.2		
					04/17/90	3		
					07/13/90	2.5		
					10/24/90	3.4		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	2.5		
					06/04/91	4		
					08/16/91	4.2		
					08/16/91	3.9		
	12/06/91	<0.5						
					12/10/91	5.6		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	7.9		
					06/30/92	5.1		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	7.2		
					01/19/93	10		
	01/20/93	<0.5						
			07/23/93	900				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Trichlorofluoromethane(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.4		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.4		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5
							11/17/94	<0.5
							06/20/96	<0.5
Vinyl chloride(µg/L)					04/22/87	<0.5		
					03/14/88	<0.5		
					06/27/88	<0.5		
					10/25/88	<0.5		
					02/10/89	<0.5		
					04/12/89	<0.5		
					07/13/89	<0.5		
					10/12/89	<0.5		
					01/18/90	<0.5		
					04/17/90	<0.5		
					07/13/90	<0.5		
					10/24/90	<0.5		
	12/20/90	<0.5						
	01/02/91	<0.5						
					02/08/91	<0.5		
					06/04/91	<0.5		
					08/16/91	<0.5		
					08/16/91	<0.5		
	12/06/91	<0.5						
					12/10/91	<0.5		
	02/05/92	<0.5						
	05/11/92	<0.5						
					06/30/92	<0.5		
					06/30/92	<0.5		
	07/29/92	<0.5						
	10/19/92	<0.5						
					12/04/92	<0.5		
					01/19/93	<0.5		
	01/20/93	<0.5						
			07/23/93	<25				
							07/18/94	<0.5
							07/28/94	<0.5
							08/01/94	<0.5
							08/04/94	<0.5
							08/08/94	<0.5
							08/08/94	<0.5
							08/24/94	<0.5

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
							11/17/94	<0.5
							06/20/96	<0.5
EPA Method 602								
1,2-Dichlorobenzene(µg/L)					03/14/88	<0.5		
					06/27/88	<0.5		
1,3-Dichlorobenzene(µg/L)					03/14/88	<0.5		
					06/27/88	<0.5		
1,4-Dichlorobenzene(µg/L)					03/14/88	<0.5		
					06/27/88	<0.5		
Benzene(µg/L)					03/14/88	<0.5		
					06/27/88	<0.5		
Chlorobenzene(µg/L)					03/14/88	<0.5		
					06/27/88	<0.5		
Ethylbenzene(µg/L)					03/14/88	<0.5		
					06/27/88	<0.5		
Toluene(µg/L)					03/14/88	<0.5		
					06/27/88	<0.5		
Total xylene isomers(µg/L)					03/14/88	<0.5		
					06/27/88	<0.5		
EPA Method 624								
1,1,1-Trichloroethane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	0.7						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
1,1,2,2-Tetrachloroethane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
1,1,2-Trichloroethane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
1,1-Dichloroethane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
1,1-Dichloroethene(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	0.89				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
1,2-Dichlorobenzene(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
1,2-Dichloroethane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
1,2-Dichloroethene (total)(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	7.9				
			01/19/93	6.8				
	06/08/93	<0.5						
			06/11/93	13				
					06/11/93	<0.5		
			08/27/93	13				
					08/27/93	<1		
			11/12/93	1				
					11/16/93	<1		
					01/21/94	<1		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	03/23/94	<1						
			06/10/94	7.6				
					06/10/94	<1		
			12/22/94	10				
	03/29/95	<1						
			03/30/95	7				
							03/31/95	<1
			05/31/95	6.5				
			12/06/95	6.2				
	06/06/96	<1						
			06/20/96	5.5				
					06/20/96	<1		
1,2-Dichloropropane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
1,3-Dichlorobenzene(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
					12/08/87	<1		
1,4-Dichlorobenzene(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
2-Butanone(µg/L)	08/13/91	<10						
	08/28/91	<10						
	09/11/91	<10						
	09/25/91	<10						
			12/04/92	<50				
			01/19/93	<50				
	06/08/93	<5						
			06/11/93	<5				
					06/11/93	<5		
			08/27/93	<10				
					08/27/93	<10		
			11/12/93	<10				
					11/16/93	<10		
			01/20/94	<10				
					01/21/94	<10		
	03/23/94	<40						
			06/10/94	<40				
					06/10/94	<40		
			12/22/94	<40				
	03/29/95	<40						
			03/30/95	<40				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
							03/31/95	<40
			05/31/95	<40				
			12/06/95	<40				
	06/06/96	<40						
			06/20/96	<40				
					06/20/96	<40		
2-Chloroethylvinylether(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<20				
			01/19/93	<20				
	06/08/93	<2						
			06/11/93	<2				
					06/11/93	<2		
			08/27/93	<10				
					08/27/93	<10		
			11/12/93	<10				
					11/16/93	<10		
			01/20/94	<10				
					01/21/94	<10		
	03/23/94	<40						
			06/10/94	<40				
					06/10/94	<40		
			12/22/94	<40				
	03/29/95	<40						
			03/30/95	<40				
							03/31/95	<40
			05/31/95	<40				
			12/06/95	<40				
	06/06/96	<40						
			06/20/96	<40				
					06/20/96	<40		
2-Hexanone(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<10				
					08/27/93	<10		
			11/12/93	<10				
					11/16/93	<10		
			01/20/94	<10				
					01/21/94	<10		
	03/23/94	<10						
			06/10/94	<10				
					06/10/94	<10		
			12/22/94	<10				
	03/29/95	<10						
			03/30/95	<10				
							03/31/95	<10
			05/31/95	<10				
			12/06/95	<10				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	06/06/96	<10						
			06/20/96	<10				
					06/20/96	<10		
4-Methyl-2-pentanone(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<50				
			01/19/93	<50				
	06/08/93	<5						
			06/11/93	<5				
					06/11/93	<5		
			08/27/93	<10				
					08/27/93	<10		
			11/12/93	<10				
					11/16/93	<10		
			01/20/94	<10				
					01/21/94	<10		
	03/23/94	<10						
			06/10/94	<10				
					06/10/94	<10		
			12/22/94	<10				
	03/29/95	<10						
			03/30/95	<10				
							03/31/95	<10
			05/31/95	<10				
			12/06/95	<10				
	06/06/96	<10						
			06/20/96	<10				
					06/20/96	<10		
Acetone(µg/L)	08/13/91	<5						
	08/28/91	<5						
	09/11/91	<5						
	09/25/91	<5						
			12/04/92	<50				
			01/19/93	<50				
	06/08/93	<5						
			06/11/93	<5				
					06/11/93	<5		
			08/27/93	<10				
					08/27/93	<10		
			11/12/93	<10				
					11/16/93	<10		
			01/20/94	<10				
					01/21/94	<10		
	03/23/94	<40						
			06/10/94	<40				
					06/10/94	<40		
			12/22/94	<40				
	03/29/95	<40						
			03/30/95	<40				
							03/31/95	<40
			05/31/95	<40				
			12/06/95	<40				
	06/06/96	<40						
			06/20/96	<40				
					06/20/96	<40		
Acrolein(µg/L)					12/08/87	<10		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	08/13/91	<5						
	08/28/91	<5						
	09/11/91	<5						
	09/25/91	<5						
			12/04/92	<100				
			01/19/93	<100				
	06/08/93	<10						
			06/11/93	<10				
					06/11/93	<10		
Acrylonitrile(µg/L)					12/08/87	<10		
	08/13/91	<5						
	08/28/91	<5						
	09/11/91	<5						
	09/25/91	<5						
			12/04/92	<50				
			01/19/93	<50				
	06/08/93	<5						
			06/11/93	<5				
					06/11/93	<5		
Benzene(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	1.8				
					06/11/93	<0.5		
			08/27/93	3				
					08/27/93	<1		
			11/12/93	12				
					11/16/93	<1		
			01/20/94	6				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	4.1				
					06/10/94	<1		
			12/22/94	3				
	03/29/95	<1						
			03/30/95	2.2				
							03/31/95	<1
			05/31/95	1.3				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Bromodichloromethane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Bromoform(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Bromomethane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<2				
					08/27/93	<2		
			11/12/93	<2				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					11/16/93	<2		
			01/20/94	<2				
					01/21/94	<2		
	03/23/94	<2						
			06/10/94	<2				
					06/10/94	<2		
			12/22/94	<2				
	03/29/95	<2						
			03/30/95	<2				
							03/31/95	<2
			05/31/95	<2				
			12/06/95	<2				
	06/06/96	<2						
			06/20/96	<2				
					06/20/96	<2		
Carbon disulfide(µg/L)	08/13/91	<0.5						
	08/28/91	2.2						
	09/11/91	1.2						
	09/25/91	2.1						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	0.6						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Carbon tetrachloride(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Chlorobenzene(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Chloroethane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<10				
			01/19/93	<10				
	06/08/93	<1						
			06/11/93	<1				
					06/11/93	<1		
			08/27/93	<2				
					08/27/93	<2		
			11/12/93	<2				
					11/16/93	<2		
			01/20/94	<2				
					01/21/94	<2		
	03/23/94	<2						
			06/10/94	<2				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					06/10/94	<2		
			12/22/94	<2				
	03/29/95	<2						
			03/30/95	<2				
							03/31/95	<2
			05/31/95	<2				
			12/06/95	<2				
	06/06/96	<2						
			06/20/96	<2				
					06/20/96	<2		
Chloroform(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Chloromethane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<2				
					08/27/93	<2		
			11/12/93	<2				
					11/16/93	<2		
			01/20/94	<2				
					01/21/94	<2		
	03/23/94	<2						
			06/10/94	<2				
					06/10/94	<2		
			12/22/94	<2				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	03/29/95	<2						
			03/30/95	<2				
							03/31/95	<2
			05/31/95	<2				
			12/06/95	<2				
	06/06/96	<2						
			06/20/96	<2				
					06/20/96	<2		
cis-1,2-Dichloroethene(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	7.9				
			01/19/93	6.8				
	06/08/93	<0.5						
			06/11/93	12				
					06/11/93	<0.5		
			01/20/94	10				
cis-1,3-Dichloropropene(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Dibromochloromethane(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Dibromomethane(µg/L)			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Dichlorodifluoromethane(µg/L)			08/27/93	<2				
					08/27/93	<2		
			11/12/93	<2				
					11/16/93	<2		
			01/20/94	<2				
					01/21/94	<2		
	03/23/94	<2						
			06/10/94	<2				
					06/10/94	<2		
			12/22/94	<2				
	03/29/95	<2						
			03/30/95	<2				
							03/31/95	<2
			05/31/95	<2				
			12/06/95	<2				
	06/06/96	<2						
			06/20/96	<2				
					06/20/96	<2		
Ethylbenzene(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	4.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Freon 113(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<10				
			01/19/93	<10				
	06/08/93	<1						
			06/11/93	<1				
					06/11/93	<1		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Methylene chloride(µg/L)					12/08/87	<1		
	08/13/91	<2						
	08/28/91	<2						
	09/11/91	<2						
	09/25/91	<2						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Styrene(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Tetrachloroethene(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Toluene(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	3.8						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Total xylene isomers(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	17						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<2				
					08/27/93	<2		
			11/12/93	<2				
					11/16/93	<2		
			01/20/94	<2				
					01/21/94	<2		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	03/23/94	<2						
			06/10/94	<2				
					06/10/94	<2		
			12/22/94	<2				
	03/29/95	<2						
			03/30/95	<2				
							03/31/95	<2
			05/31/95	<2				
			12/06/95	<2				
	06/06/96	<2						
			06/20/96	<2				
					06/20/96	<2		
trans-1,2-Dichloroethene(µg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	1.2				
					06/11/93	<0.5		
			01/20/94	<1				
trans-1,3-Dichloropropene(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Trichloroethene(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	700				
			01/19/93	750				
	06/08/93	<0.5						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			06/11/93	860				
					06/11/93	9.3		
			08/27/93	1000				
					08/27/93	15		
			11/12/93	780				
					11/16/93	13		
			01/20/94	530				
					01/21/94	4		
	03/23/94	<0.5						
			06/10/94	600				
					06/10/94	4.6		
			12/22/94	750				
	03/29/95	<0.5						
			03/30/95	550				
							03/31/95	<0.5
			05/31/95	520				
			12/06/95	570				
	06/06/96	<0.5						
			06/20/96	380				
					06/20/96	17		
Trichlorofluoromethane(μg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<1				
					08/27/93	<1		
			11/12/93	<1				
					11/16/93	<1		
			01/20/94	<1				
					01/21/94	<1		
	03/23/94	<1						
			06/10/94	<1				
					06/10/94	<1		
			12/22/94	<1				
	03/29/95	<1						
			03/30/95	<1				
							03/31/95	<1
			05/31/95	<1				
			12/06/95	<1				
	06/06/96	<1						
			06/20/96	<1				
					06/20/96	<1		
Vinyl acetate(μg/L)	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<10				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					08/27/93	<10		
			11/12/93	<10				
					11/16/93	<10		
			01/20/94	<10				
					01/21/94	<10		
	03/23/94	<10						
			06/10/94	<10				
					06/10/94	<10		
			12/22/94	<10				
	03/29/95	<10						
			03/30/95	<10				
							03/31/95	<10
			05/31/95	<10				
			12/06/95	<10				
	06/06/96	<10						
			06/20/96	<10				
					06/20/96	<10		
Vinyl chloride(µg/L)					12/08/87	<1		
	08/13/91	<0.5						
	08/28/91	<0.5						
	09/11/91	<0.5						
	09/25/91	<0.5						
			12/04/92	<5				
			01/19/93	<5				
	06/08/93	<0.5						
			06/11/93	<0.5				
					06/11/93	<0.5		
			08/27/93	<2				
					08/27/93	<2		
			11/12/93	<2				
					11/16/93	<2		
			01/20/94	<2				
					01/21/94	<2		
	03/23/94	<2						
			06/10/94	<2				
					06/10/94	<2		
			12/22/94	<2				
	03/29/95	<2						
			03/30/95	<2				
							03/31/95	<2
			05/31/95	<2				
			12/06/95	<2				
	06/06/96	<2						
			06/20/96	<2				
					06/20/96	<2		
EPA Method 625								
1,2,4-Trichlorobenzene(µg/L)					12/08/87	<1		
			01/19/93	<4				
	01/20/93	<4						
1,2-Dichlorobenzene(µg/L)					12/08/87	<1		
			01/19/93	<4				
	01/20/93	<4						
1,2-Diphenylhydrazine(µg/L)					12/08/87	<1		
			01/19/93	<4				
	01/20/93	<4						
1,3-Dichlorobenzene(µg/L)					12/08/87	<1		
			01/19/93	<3				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	01/20/93	<3						
1,4-Dichlorobenzene(μg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
2,4,5-Trichlorophenol(μg/L)	01/20/93	<4	01/19/93	<4				
2,4,6-Trichlorophenol(μg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
2,4-Dichlorophenol(μg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
2,4-Dimethylphenol(μg/L)	01/20/93	<4	01/19/93	<4	12/08/87	<1		
2,4-Dinitrophenol(μg/L)	01/20/93	<10	01/19/93	<10	12/08/87	<10		
2,4-Dinitrotoluene(μg/L)	01/20/93	<10	01/19/93	<10	12/08/87	<1		
2,6-Dinitrotoluene(μg/L)	01/20/93	<2	01/19/93	<2	12/08/87	<1		
2-Chloronaphthalene(μg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
2-Chlorophenol(μg/L)	01/20/93	<4	01/19/93	<4	12/08/87	<1		
2-Methyl Phenol(μg/L)	01/20/93	<3	01/19/93	<3				
2-Methyl-4,6-dinitrophenol(μg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
2-Methylnaphthalene(μg/L)	01/20/93	<3	01/19/93	<3				
2-Nitroaniline(μg/L)	01/20/93	<10	01/19/93	<10				
2-Nitrophenol(μg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
3,3'-Dichlorobenzidine(μg/L)	01/20/93	<20	01/19/93	<20	12/08/87	<1		
3-Nitroaniline(μg/L)	01/20/93	<10	01/19/93	<10				
4-Bromophenylphenylether(μg/L)	01/20/93	<4	01/19/93	<4	12/08/87	<1		
4-Chloro-3-methylphenol(μg/L)	01/20/93	<4	01/19/93	<4	12/08/87	<1		
4-Chloroaniline(μg/L)	01/20/93	<10	01/19/93	<10				
4-Chlorophenylphenylether(μg/L)	01/20/93	<4	01/19/93	<4	12/08/87	<1		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
4-Methyl Phenol(µg/L)			01/19/93	<4				
	01/20/93	<4						
4-Nitroaniline(µg/L)			01/19/93	<10				
	01/20/93	<10						
4-Nitrophenol(µg/L)					12/08/87	<20		
			01/19/93	<30				
	01/20/93	<30						
Acenaphthene(µg/L)					12/08/87	<1		
			01/19/93	<5				
	01/20/93	<5						
Acenaphthylene(µg/L)					12/08/87	<1		
			01/19/93	<3				
	01/20/93	<3						
Aniline(µg/L)			01/19/93	<10				
	01/20/93	<10						
Anthracene(µg/L)					12/08/87	<1		
			01/19/93	<4				
	01/20/93	<4						
Benzidine(µg/L)					12/08/87	<40		
			01/19/93	<50				
	01/20/93	<50						
Benzo(a)anthracene(µg/L)					12/08/87	<1		
			01/19/93	<3				
	01/20/93	<3						
Benzo(a)pyrene(µg/L)					12/08/87	<1		
			01/19/93	<3				
	01/20/93	<3						
Benzo(b)fluoranthene(µg/L)					12/08/87	<1		
			01/19/93	<10				
	01/20/93	<10						
Benzo(g,h,i)perylene(µg/L)					12/08/87	<1		
			01/19/93	<3				
	01/20/93	<3						
Benzo(k)fluoranthene(µg/L)					12/08/87	<1		
			01/19/93	<10				
	01/20/93	<10						
Benzoic Acid(µg/L)			01/19/93	<10				
	01/20/93	<10						
Benzyl Alcohol(µg/L)			01/19/93	<10				
	01/20/93	<10						
Bis(2-chloroethoxy)methane(µg/L)					12/08/87	<1		
			01/19/93	<3				
	01/20/93	<3						
Bis(2-chloroethyl)ether(µg/L)					12/08/87	<1		
			01/19/93	<3				
	01/20/93	<3						
Bis(2-chloroisopropyl)ether(µg/L)					12/08/87	<1		
			01/19/93	<3				
	01/20/93	<3						
Bis(2-ethylhexyl)phthalate(µg/L)					12/08/87	<100		
			01/19/93	16				
	01/20/93	<10						
Butylbenzylphthalate(µg/L)					12/08/87	<1		
			01/19/93	<3				
	01/20/93	<3						
C16 Fatty Acid(µg/L)			01/19/93	30				
			01/19/93	50				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
Chrysene(µg/L)	01/20/93	<2	01/19/93	<2	12/08/87	<1		
Di-n-octylphthalate(µg/L)	01/20/93	<4	01/19/93	<4	12/08/87	<1		
Dibenzo(a,h)anthracene(µg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
Dibenzofuran(µg/L)	01/20/93	<3	01/19/93	<3				
Dibutylphthalate(µg/L)	01/20/93	<5	01/19/93	<5	12/08/87	<1		
Diethylphthalate(µg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
Dimethylphthalate(µg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
Fluoranthene(µg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
Fluorene(µg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
Hexachlorobenzene(µg/L)	01/20/93	<4	01/19/93	<4	12/08/87	<1		
Hexachlorobutadiene(µg/L)	01/20/93	<4	01/19/93	<4	12/08/87	<1		
Hexachlorocyclopentadiene(µg/L)	01/20/93	<20	01/19/93	<20	12/08/87	<1		
Hexachloroethane(µg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
Indeno(1,2,3-c,d)pyrene(µg/L)	01/20/93	<4	01/19/93	<4	12/08/87	<1		
Isophorone(µg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
Molecular Sulfur(µg/L)			01/19/93	50				
N-Nitrosodi-n-propylamine(µg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
N-Nitrosodimethylamine(µg/L)	01/20/93	<10	01/19/93	<10	12/08/87	<1		
N-Nitrosodiphenylamine(µg/L)	01/20/93	<10	01/19/93	<10	12/08/87	<1		
Naphthalene(µg/L)	01/20/93	<3	01/19/93	<3	12/08/87	<1		
Nitrobenzene(µg/L)					12/08/87	<1		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			01/19/93	<4				
	01/20/93	<4						
Pentachlorophenol(µg/L)					12/08/87	<1		
			01/19/93	<10				
	01/20/93	<10						
Phenanthrene(µg/L)					12/08/87	<1		
			01/19/93	<4				
	01/20/93	<4						
Phenol(µg/L)					12/08/87	<1		
			01/19/93	<5				
	01/20/93	<5						
Pyrene(µg/L)					12/08/87	<1		
			01/19/93	<2				
	01/20/93	<2						
Total C12-C35 Hydrocarbons(µg/L)			01/19/93	2000				
Field measurements								
Field pH(Units)					12/08/87	7.34		
					03/14/88	8.12		
					06/27/88	7.54		
			05/31/95	7.64				
Field Specific Conductance(µmhos/cm)					12/08/87	2100		
					03/14/88	2450		
					06/27/88	2600		
			05/31/95	3040				
Field Temperature(Degrees C)					12/08/87	16.5		
					03/14/88	19.5		
					06/27/88	20.8		
			05/31/95	20.3				
GW Chemistry								
Bicarbonate Alk (as $CaCO_3$)(mg/L)					12/08/87	435		
					10/25/88	440		
					06/04/91	480		
	08/13/91	150						
	08/28/91	160						
	09/11/91	120						
	09/25/91	160						
			12/04/92	630				
							03/31/95	<1
Calcium(mg/L)					12/08/87	63		
					10/25/88	44		
					06/04/91	37		
	08/13/91	140						
	08/28/91	150						
	09/11/91	150						
	09/25/91	140						
			12/04/92	40				
							03/31/95	2.8
Carbonate Alk (as $CaCO_3$)(mg/L)					12/08/87	<1		
					10/25/88	<1		
					06/04/91	<1		
	08/13/91	<1						
	08/28/91	<1						
	09/11/91	<1						
	09/25/91	<1						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			12/04/92	<1				
							03/31/95	320
Hydroxide Alk (as $CaCO_3$)(mg/L)					12/08/87	<1		
					10/25/88	<1		
					06/04/91	<1		
	08/13/91	<1						
	08/28/91	<1						
	09/11/91	<1						
	09/25/91	<1						
			12/04/92	<1				
							03/31/95	130
Nitrate (as N)(mg/L)			01/20/94	25				
					01/21/94	18		
Nitrate (as NO_3)(mg/L)			01/20/94	110.75				
					01/21/94	79.74		
							03/31/95	<0.5
Nitrate plus Nitrite (as N)(mg/L)					06/04/91	6.4		
	08/13/91	<0.1						
	08/28/91	<0.1						
	09/11/91	<0.1						
	09/25/91	<0.1						
			12/04/92	13				
Nitrate plus Nitrite (as NO_3)(mg/L)					12/08/87	170		
					10/25/88	1.5		
					06/04/91	28		
	08/13/91	<0.4						
	08/28/91	<0.4						
	09/11/91	<0.4						
	09/25/91	<0.4						
			12/04/92	59				
Potassium(mg/L)					12/08/87	23		
					10/25/88	22		
					06/04/91	25		
	08/13/91	26						
	08/28/91	28						
	09/11/91	29						
	09/25/91	28						
			12/04/92	24				
							03/31/95	93
Surfactants(mg/L)					12/08/87	0.02		
					10/25/88	<0.02		
							03/31/95	<0.5
Total Alkalinity (as $CaCO_3$)(mg/L)					12/08/87	435		
					10/25/88	440		
					06/04/91	480		
	08/13/91	150						
	08/28/91	160						
	09/11/91	120						
	09/25/91	160						
			12/04/92	630				
							03/31/95	450
Total dissolved solids (TDS)(mg/L)					12/08/87	1760		
					10/25/88	1500		
					06/04/91	1600		
	08/13/91	1900						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	08/28/91	1700						
	09/11/91	1600						
	09/25/91	1600						
			12/04/92	1600				
							03/31/95	960
GW Indicators								
Specific Conductance(μmhos/cm)					12/08/87	2860		
					10/25/88	2810		
					06/04/91	2680		
	08/13/91	2130						
	08/28/91	2200						
	09/11/91	2200						
	09/25/91	2090						
			12/04/92	2430				
							03/31/95	1700
Total Organic Carbon (TOC)(mg/L)	08/13/91	1.1						
	08/13/91	1.6						
	08/13/91	2						
	08/13/91	2						
	08/28/91	0.7						
	08/28/91	0.7						
	08/28/91	0.7						
	08/28/91	0.7						
	09/11/91	1.3						
	09/11/91	1.3						
	09/11/91	1.3						
	09/11/91	1.3						
	09/25/91	1.6						
	09/25/91	2.3						
	09/25/91	1.6						
	09/25/91	2.1						
Total Organic Halogen (TOX) (mg/L)	08/13/91	0.03						
	08/13/91	0.02						
	08/13/91	0.02						
	08/13/91	<0.02						
	08/13/91	0.02						
	08/13/91	0.02						
	08/13/91	0.02						
	08/13/91	0.03						
	08/28/91	0.02						
	08/28/91	<0:02						
	08/28/91	0.03						
	08/28/91	<0.02						
	08/28/91	0.02						
	09/11/91	<0.02						
	09/11/91	<0.02						
	09/11/91	<0.02						
	09/11/91	<0.02						
	09/11/91	<0.02						
	09/11/91	<0.02						
	09/11/91	<0.02						
	09/11/91	<0.02						
pH(Units)					12/08/87	7.7		
					10/25/88	7.6		
					06/04/91	7.6		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	08/13/91	7.9						
	08/28/91	8						
	09/11/91	6.3						
	09/25/91	7.8						
			12/04/92	7.9				
							03/31/95	11
GW Quality								
Chloride(mg/L)					12/08/87	460		
					10/25/88	400		
					06/04/91	360		
	08/13/91	190						
	08/28/91	190						
	09/11/91	170						
	09/25/91	180						
			12/04/92	330				
							03/31/95	76
Fluoride(mg/L)							03/31/95	0.42
Total Hardness (as $CaCO_3$)(mg/L)							03/31/95	7
Iron(mg/L)					12/08/87	1.5		
					10/25/88	0.15		
					06/04/91	<0.1		
	08/13/91	<0.1						
	08/28/91	<0.1						
	09/11/91	<0.1						
	09/25/91	<0.1						
			12/04/92	1				
							03/31/95	<0.1
Low Level Phenolics(mg/L)	08/13/91	<0.005						
	08/28/91	0.009						
	09/11/91	<0.005						
Manganese(mg/L)					12/08/87	0.02		
					10/25/88	<0.01		
					06/04/91	<0.05		
	08/13/91	0.24						
	08/28/91	0.3						
	09/11/91	0.22						
	09/25/91	0.26						
			12/04/92	0.31				
							03/31/95	<0.03
Phenolics(mg/L)	09/25/91	<0.05						
Sodium(mg/L)					12/08/87	510		
					10/25/88	480		
					06/04/91	410		
	08/13/91	290						
	08/28/91	330						
	09/11/91	320						
	09/25/91	320						
			12/04/92	440				
							03/31/95	280
Sulfate(mg/L)					12/08/87	320		
					10/25/88	330		
					06/04/91	270		
	08/13/91	860						
	08/28/91	820						
	09/11/91	670						
	09/25/91	790						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			12/04/92	200				
							03/31/95	180
High Explosives								
HMX(μg/L)					05/04/87	<20		
					01/06/88	<8		
					01/06/88	<8		
					03/21/88	<15		
					06/27/88	<20		
					10/25/88	<20		
					02/10/89	<20		
					04/12/89	<20		
					07/13/89	<30		
					10/12/89	<10		
					01/18/90	<15		
					04/17/90	<15		
					07/13/90	<20		
					10/24/90	<20		
	12/20/90	<20						
	01/02/91	<20						
					02/06/91	<20		
					06/04/91	<20		
	08/13/91	<20						
					08/16/91	<20		
	08/28/91	<20						
	09/11/91	<20						
	09/25/91	<20						
	12/06/91	<0.83						
	12/06/91	<20						
					12/10/91	<0.83		
					12/10/91	<20		
	02/05/92	<20						
	05/11/92	<20						
					06/30/92	<20		
	07/29/92	<20						
	10/19/92	<20						
			12/04/92	<20				
					12/04/92	<20		
			01/19/93	<20				
					01/19/93	<20		
	01/20/93	<20						
	06/08/93	<20						
			06/11/93	<20				
					06/11/93	<20		
					06/22/93	<0.785		
			06/22/93	<0.785				
			08/27/93	<20				
					08/27/93	<20		
			11/12/93	<10				
			11/12/93	<20				
					11/16/93	<10		
					11/16/93	<20		
			01/20/94	<10				
			01/20/94	<20				
					01/21/94	<10		
	03/23/94	<10						
			06/10/94	<10				
					06/10/94	<10		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			12/22/94	<5				
	03/29/95	<5						
			03/30/95	<5				
							03/31/95	<5
			05/31/95	<5				
			12/06/95	<5				
	06/06/96	<5						
							06/20/96	<5
			06/20/96	<5				
					06/20/96	<5		
HMX(µg/g)	12/19/90	0.011						
	12/19/90	0.01						
	12/19/90	0.191						
							08/02/94	<0.005
RDX(µg/L)					05/04/87	<20		
					01/06/88	<20		
					01/06/88	<20		
					03/21/88	<20		
					06/27/88	<20		
					10/25/88	<30		
					02/10/89	<20		
					04/12/89	<20		
					07/13/89	<30		
					10/12/89	<10		
					01/18/90	<30		
					04/17/90	<20		
					07/13/90	<40		
					10/24/90	<30		
	12/20/90	<30						
	01/02/91	<30						
					02/06/91	<30		
					06/04/91	<30		
	08/13/91	<20						
					08/16/91	<20		
	08/28/91	<20						
	09/11/91	<20						
	09/25/91	<30						
	12/06/91	<0.731						
	12/06/91	<30						
					12/10/91	<0.731		
					12/10/91	<30		
	02/05/92	<30						
	05/11/92	<30						
					06/30/92	<30		
	07/29/92	<30						
	10/19/92	<30						
			12/04/92	<30				
					12/04/92	<30		
			01/19/93	<30				
					01/19/93	<30		
	01/20/93	<30						
	06/08/93	<30						
			06/11/93	<30				
					06/11/93	<30		
					06/22/93	<0.71		
			06/22/93	<0.71				
			08/27/93	<30				
					08/27/93	<30		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			11/12/93	<10				
			11/12/93	<30				
					11/16/93	<10		
					11/16/93	<30		
			01/20/94	<10				
			01/20/94	<30				
					01/21/94	<10		
	03/23/94	<10						
			06/10/94	<10				
					06/10/94	<10		
			12/22/94	<5				
	03/29/95	<5						
			03/30/95	<5				
							03/31/95	<5
			05/31/95	<5				
			12/06/95	<5				
	06/06/96	<5						
							06/20/96	<5
			06/20/96	<5				
					06/20/96	<5		
RDX(µg/g)	12/13/90	<0.001						
	12/19/90	<0.001						
	12/19/90	<0.001						
	12/19/90	0.005						
							08/02/94	<0.02
TNT(µg/L)					05/04/87	<20		
					01/06/88	<20		
					01/06/88	<20		
					03/21/88	<15		
					06/27/88	<20		
					10/25/88	<40		
					02/10/89	<20		
					04/12/89	<20		
					07/13/89	<30		
					10/12/89	<10		
					01/18/90	<30		
					04/17/90	<30		
					07/13/90	<40		
					10/24/90	<30		
	12/20/90	<30						
	01/02/91	<30						
					02/06/91	<30		
					06/04/91	<30		
	08/13/91	<30						
					08/16/91	<30		
	08/28/91	<30						
	09/11/91	<30						
	09/25/91	<30						
	12/06/91	<0.469						
	12/06/91	<30						
					12/10/91	<0.469		
					12/10/91	<30		
	02/05/92	<30						
	05/11/92	<30						
					06/30/92	<30		
	07/29/92	<30						
	10/19/92	<30						
			12/04/92	<30				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					12/04/92	<30		
			01/19/93	<30				
					01/19/93	<30		
	01/20/93	<30						
	06/08/93	<30						
			06/11/93	<30				
					06/11/93	<30		
					06/22/93	<0.501		
			06/22/93	<0.501				
			08/27/93	<30				
					08/27/93	<30		
			11/12/93	<5				
			11/12/93	<30				
					11/16/93	<5		
					11/16/93	<30		
			01/20/94	<5				
			01/20/94	<30				
					01/21/94	<5		
	03/23/94	<5						
			06/10/94	<5				
					06/10/94	<5		
			12/22/94	<5				
	03/29/95	<5						
			03/30/95	<5				
							03/31/95	<5
TNT(µg/g)	12/13/90	<0.001						
	12/19/90	<0.001						
	12/19/90	<0.001						
	12/19/90	<0.001						
							08/02/94	<0.02
Inorganics								
Cyanide(mg/L)					01/21/94	<0.02		
Silica (as SiO_2)(mg/L)					06/04/91	22		
	08/13/91	66						
	08/28/91	67						
	09/11/91	66						
	09/25/91	66						
Dissolved Metals								
Aluminum(mg/L)							03/31/95	<0.2
Antimony(mg/L)			06/11/93	<0.03				
					06/11/93	<0.03		
			08/27/93	<0.01				
					08/27/93	<0.01		
			11/12/93	<0.005				
					11/16/93	<0.005		
			01/20/94	<0.05				
					01/21/94	<0.05		
	03/23/94	<0.005						
			06/10/94	<0.005				
					06/10/94	<0.05		
			12/22/94	<0.005				
	03/29/95	<0.005						
Arsenic(mg/L)	08/13/91	0.003						
	08/28/91	0.003						
	09/11/91	<0.002						
	09/25/91	0.003						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			06/11/93	0.0024				
					06/11/93	0.0038		
			08/27/93	0.0078				
					08/27/93	<0.005		
			11/12/93	0.051				
					11/16/93	<0.005		
			01/20/94	0.0059				
					01/21/94	0.0059		
	03/23/94	0.0022						
			06/10/94	0.0032				
					06/10/94	<0.002		
			12/22/94	0.0031				
	03/29/95	0.003						
							03/31/95	0.023
Barium(mg/L)	08/13/91	<0.05						
	08/28/91	<0.05						
	09/11/91	<0.05						
	09/25/91	<0.05						
			06/11/93	0.03				
					06/11/93	0.028		
			08/27/93	0.078				
					08/27/93	<0.05		
			11/12/93	0.75				
					11/16/93	<0.05		
			01/20/94	<0.05				
					01/21/94	0.086		
	03/23/94	<0.05						
			06/10/94	0.19				
					06/10/94	0.035		
			12/22/94	0.06				
	03/29/95	<0.025						
							03/31/95	<0.025
Beryllium(mg/L)			06/11/93	<0.0002				
					06/11/93	<0.0002		
			08/27/93	0.0019				
					08/27/93	<0.0005		
			11/12/93	0.018				
			01/20/94	<0.01				
					01/21/94	<0.01		
	03/23/94	<0.0005						
			06/10/94	<0.01				
					06/10/94	<0.01		
			12/22/94	<0.0005				
	03/29/95	<0.0005						
Boron(mg/L)					11/16/93	2.8		
Cadmium(mg/L)	08/13/91	<0.0005						
	08/28/91	<0.0005						
	09/11/91	<0.0005						
	09/25/91	<0.0005						
			06/11/93	<0.0005				
					06/11/93	<0.0005		
			08/27/93	0.0021				
					08/27/93	0.001		
			11/12/93	0.0035				
					11/16/93	<0.001		
			01/20/94	<0.001				
					01/21/94	<0.001		
	03/23/94	<0.001						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			06/10/94	<0.0005				
					06/10/94	<0.0005		
			12/22/94	<0.0005				
	03/29/95	<0.0005						
							03/31/95	<0.0005
Chromium(mg/L)	08/13/91	<0.005						
	08/28/91	<0.005						
	09/11/91	<0.005						
	09/25/91	<0.005						
			06/11/93	<0.005				
					06/11/93	<0.005		
			08/27/93	<0.01				
					08/27/93	<0.01		
			11/12/93	0.16				
					11/16/93	<0.01		
			01/20/94	<0.01				
					01/21/94	0.02		
	03/23/94	<0.01						
			06/10/94	<0.01				
					06/10/94	<0.01		
			12/22/94	<0.01				
	03/29/95	<0.01						
							03/31/95	<0.01
Cobalt(mg/L)			06/11/93	<0.01				
					06/11/93	<0.01		
			08/27/93	<0.05				
					08/27/93	<0.05		
			11/12/93	0.051				
					11/16/93	<0.05		
			01/20/94	<0.05				
					01/21/94	<0.05		
			06/10/94	<0.05				
					06/10/94	<0.05		
			12/22/94	<0.05				
Lead(mg/L)	08/13/91	<0.002						
	08/28/91	<0.002						
	09/11/91	<0.002						
	09/25/91	<0.002						
			06/11/93	<0.002				
					06/11/93	<0.002		
			08/27/93	0.016				
					08/27/93	<0.005		
			11/12/93	0.053				
					11/16/93	<0.005		
			01/20/94	<0.002				
					01/21/94	0.0057		
	03/23/94	<0.002						
			06/10/94	<0.002				
					06/10/94	<0.002		
			12/22/94	<0.002				
	03/29/95	<0.002						
							03/31/95	<0.002
Magnesium(mg/L)					12/08/87	67		
					10/25/88	53		
					06/04/91	42		
	08/13/91	38						
	08/28/91	43						
	09/11/91	45						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	09/25/91	38						
			12/04/92	33				
							03/31/95	<0.5
Mercury(mg/L)	08/13/91	<0.0005						
	08/28/91	<0.0005						
	09/11/91	<0.0005						
	09/25/91	<0.0005						
			06/11/93	<0.0002				
					06/11/93	<0.0002		
			08/27/93	0.0016				
					08/27/93	<0.0005		
			11/12/93	<0.0005				
					11/16/93	<0.0005		
			01/20/94	<0.0005				
					01/21/94	<0.0005		
	03/23/94	<0.0002						
			06/10/94	<0.0002				
					06/10/94	<0.0002		
			12/22/94	<0.0002				
	03/29/95	<0.0002						
							03/31/95	<0.0002
Nickel(mg/L)			06/11/93	<0.02				
					06/11/93	<0.02		
			08/27/93	0.019				
					08/27/93	<0.005		
			11/12/93	0.1				
					11/16/93	<0.005		
			01/20/94	<0.05				
					01/21/94	<0.05		
	03/23/94	<0.005						
			06/10/94	<0.005				
					06/10/94	<0.005		
			12/22/94	<0.005				
	03/29/95	<0.005						
							03/31/95	<0.1
Selenium(mg/L)	08/13/91	<0.002						
	08/28/91	<0.002						
	09/11/91	<0.002						
	09/25/91	<0.002						
			06/11/93	0.26				
					06/11/93	0.43		
			08/27/93	0.37				
					08/27/93	0.47		
			11/12/93	0.024				
					11/16/93	0.29		
			01/20/94	0.35				
					01/21/94	0.51		
	03/23/94	<0.002						
			06/10/94	0.22				
					06/10/94	0.37		
			12/22/94	0.29				
	03/29/95	<0.002						
							03/31/95	<0.002
Silver(mg/L)	08/13/91	<0.05						
	08/28/91	<0.05						
	09/11/91	<0.05						
	09/25/91	<0.05						
			06/11/93	<0.01				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					06/11/93	<0.01		
			08/27/93	<0.001				
					08/27/93	<0.001		
			11/12/93	<0.001				
					11/16/93	<0.001		
			01/20/94	<0.001				
					01/21/94	<0.001		
	03/23/94	<0.001						
			06/10/94	<0.001				
					06/10/94	<0.001		
			12/22/94	<0.001				
	03/29/95	<0.001						
							03/31/95	<0.001
Vanadium(mg/L)			06/11/93	<0.008				
					06/11/93	<0.008		
			08/27/93	<0.02				
					08/27/93	<0.02		
			11/12/93	0.31				
					11/16/93	<0.05		
			01/20/94	<0.05				
					01/21/94	<0.05		
			06/10/94	<0.02				
					06/10/94	<0.02		
			12/22/94	<0.05				
Zinc(mg/L)					12/08/87	<0.01		
					10/25/88	0.06		
					06/04/91	<0.05		
	08/13/91	<0.05						
	08/28/91	<0.05						
	09/11/91	<0.05						
	09/25/91	0.11						
			12/04/92	<0.05				
							03/31/95	<0.05
Total Metals (mg/L)								
Antimony(mg/L)					01/19/93	<0.2		
	06/08/93	<0.03						
Arsenic(mg/L)			12/04/92	0.0062				
					01/19/93	0.0039		
	06/08/93	<0.002						
Barium(mg/L)			12/04/92	0.058				
	06/08/93	0.026						
Beryllium(mg/L)					01/19/93	<0.01		
	06/08/93	<0.0002						
Cadmium(mg/L)			12/04/92	<0.0005				
					01/19/93	<0.05		
	06/08/93	<0.0005						
Chromium(mg/L)			12/04/92	<0.01				
					01/19/93	<0.05		
	06/08/93	<0.005						
Cobalt(mg/L)	06/08/93	<0.01						
Copper(mg/L)					12/08/87	<0.02		
					10/25/88	<0.02		
					06/04/91	<0.05		
	08/13/91	<0.05						
	08/28/91	<0.05						
	09/11/91	<0.05						
	09/25/91	<0.05						

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			12/04/92	<0.05				
							03/31/95	<0.05
					01/19/93	<0.05		
Lead(mg/L)			12/04/92	<0.002				
					01/19/93	<0.2		
	06/08/93	<0.002						
Mercury(mg/L)			12/04/92	<0.0002				
					01/19/93	<0.0002		
	06/08/93	<0.0002						
Nickel(mg/L)					01/19/93	<0.1		
	06/08/93	<0.02						
Selenium(mg/L)			12/04/92	0.2				
					01/19/93	0.37		
	06/08/93	<0.002						
Silver(mg/L)			12/04/92	<0.05				
					01/19/93	<0.05		
	06/08/93	<0.01						
Thallium(mg/L)					01/19/93	<0.4		
Vanadium(mg/L)	06/08/93	<0.008						
Zinc(mg/L)					01/19/93	<0.05		
Radiologicals								
Gross alpha(pCi/L)			01/19/93	195				
			01/19/93	323				
	06/08/93	<3.6						
			06/11/93	207.9				
					06/11/93	149.67		
			08/27/93	163.7				
			08/27/93	152.76				
					08/27/93	102.51		
					08/27/93	90.67		
			08/27/93	52				
					08/27/93	76		
			11/12/93	80				
					11/16/93	101		
					11/16/93	83		
			01/20/94	0.79				
			01/20/94	<45				
					01/22/94	65.5		
					01/22/94	92		
	03/23/94	6.15						
			06/10/94	240				
					06/10/94	146		
			06/10/94	58				
					06/10/94	65		
			12/22/94	67.1				
			12/22/94	34				
	03/29/95	<4.02						
	03/29/95	<1.05						
Gross beta(pCi/L)			01/19/93	138				
			01/19/93	262				
	06/08/93	27.35						
			06/11/93	122.35				
					06/11/93	50.67		
			08/27/93	71.06				
			08/27/93	61.71				
					08/27/93	55.92		
					08/27/93	47.48		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			08/27/93	36				
					08/27/93	49		
			11/12/93	26				
					11/16/93	66.4		
					11/16/93	56		
			01/20/94	<0.72				
			01/20/94	<53				
					01/22/94	31.3		
					01/22/94	36		
	03/23/94	28.3						
			06/10/94	73.9				
					06/10/94	54.9		
			06/10/94	39				
					06/10/94	32		
			12/22/94	25.5				
			12/22/94	<16				
	03/29/95	26.5						
Radium 226(pCi/L)	06/08/93	0.66						
			06/11/93	2.57				
					06/11/93	0.8		
			06/11/93	2.76				
					08/27/93	0.53		
					08/27/93	0.44		
			08/27/93	0.26				
					08/27/93	0.23		
			08/30/93	0.84				
			11/12/93	0.61				
			11/12/93	<0.26				
					11/16/93	0.58		
					11/16/93	<0.24		
			01/20/94	1.03				
			01/20/94	0.059				
					01/22/94	0.51		
					01/22/94	<0.22		
			06/10/94	0.8				
					06/10/94	0.28		
					06/10/94	<0.32		
			06/10/94	<0.44				
			12/22/94	0.32				
			12/22/94	<0.69				
Radium 228(pCi/L)	06/08/93	<0.65						
			06/11/93	1.3				
					06/11/93	<0.64		
			06/11/93	2.17				
					08/27/93	<0.77		
					08/27/93	<0.64		
			08/27/93	<0.53				
					08/27/93	<0.55		
			08/30/93	0.5				
			11/12/93	<0.84				
			11/12/93	<0.69				
					11/16/93	<0.88		
					11/16/93	<0.67		
			01/20/94	5.12				
			01/20/94	0.76				
					01/22/94	1.56		
					01/22/94	<0.66		
					06/10/94	<0.61		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
			06/10/94	<0.8				
			12/22/94	0.88				
Tritium(pCi/L)	10/19/92	5.34						
			01/19/93	<173				
	06/08/93	<190						
			06/11/93	<200				
					06/11/93	<190		
			08/27/93	<86				
			08/27/93	<86				
					08/27/93	<86		
					08/27/93	<90		
			08/27/93	<200				
					08/27/93	<200		
			11/12/93	<152				
			11/12/93	<230				
					11/16/93	<728		
					11/16/93	<220		
			01/20/94	<123				
			01/20/94	<190				
					01/22/94	<119		
					01/22/94	<190		
	03/23/94	<85.6						
			06/10/94	<84.4				
					06/10/94	<81.6		
			06/10/94	<240				
					06/10/94	<250		
			12/22/94	<98.7				
			12/22/94	<240				
	03/29/95	<79.9						
Uranium 234 and Uranium 233(pCi/L)			01/19/93	58.62				
	06/08/93	0.34						
	06/08/93	0.36						
			06/11/93	38.27				
					06/11/93	52.48		
			08/27/93	41.96				
			08/27/93	34.63				
					08/27/93	42.33		
					08/27/93	42.53		
			08/27/93	28.6				
					08/27/93	32.5		
			11/12/93	6.28				
			11/12/93	38.4				
					11/16/93	47.1		
					11/16/93	54.6		
			01/20/94	0.49				
			01/20/94	30.7				
					01/22/94	49		
					01/22/94	42.6		
	03/23/94	0.33						
			06/10/94	39.1				
					06/10/94	47.6		
			06/10/94	31.2				
					06/10/94	42.5		
			12/22/94	29.2				
			12/22/94	24.7				
	03/29/95	0.182						
Uranium 235 and Uranium 236(pCi/L)			01/19/93	2.56				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
	06/08/93	0.08						
	06/08/93	<0.15						
			06/11/93	4.64				
					06/11/93	3.67		
			08/27/93	1.58				
			08/27/93	1.86				
					08/27/93	2.62		
					08/27/93	2.36		
			08/27/93	1.31				
					08/27/93	1.78		
			11/12/93	0.17				
			11/12/93	1.53				
					11/16/93	2.76		
					11/16/93	2.26		
			01/20/94	0.27				
			01/20/94	1.42				
					01/22/94	3.51		
					01/22/94	3		
	03/23/94	0.04						
			06/10/94	1.63				
					06/10/94	2.31		
			06/10/94	3.11				
					06/10/94	4.8		
			12/22/94	2.56				
			12/22/94	1.3				
	03/29/95	<0.032						
Uranium 238(pCi/L)			01/19/93	55.82				
	06/08/93	0.14						
	06/08/93	<0.19						
			06/11/93	36.38				
					06/11/93	56.85		
			08/27/93	31.12				
			08/27/93	29.29				
					08/27/93	42.67		
					08/27/93	42.28		
			08/27/93	24.5				
					08/27/93	37.5		
			11/12/93	3.12				
			11/12/93	32.9				
					11/16/93	49.3		
					11/16/93	56.9		
			01/20/94	0.42				
			01/20/94	27.6				
					01/22/94	47.1		
					01/22/94	43		
	03/23/94	0.25						
			06/10/94	33.1				
					06/10/94	46.9		
			06/10/94	27.8				
					06/10/94	42.1		
			12/22/94	23.4				
			12/22/94	22				
	03/29/95	<0.026						
Gamma Spectroscopy								
Actinium 228(pCi/L)			08/27/93	<21				
					08/27/93	<22		
			11/12/93	<20				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					11/16/93	<28		
			01/20/94	<27				
					01/22/94	<29		
			06/10/94	<36				
					06/10/94	<34		
			12/22/94	<43				
Americium 241(pCi/L)			08/27/93	<15				
					08/27/93	<14		
Antimony 125(pCi/L)			08/27/93	<10				
					08/27/93	<9		
Beryllium 7(pCi/L)			08/27/93	<28				
					08/27/93	<48		
Bismuth 212(pCi/L)			08/27/93	<61				
					08/27/93	<52		
Bismuth 214(pCi/L)			08/27/93	<12				
					08/27/93	<11		
			06/10/94	14				
					06/10/94	21		
			12/22/94	<22				
Cesium 134(pCi/L)			08/27/93	<6.9				
					08/27/93	<6.4		
			12/22/94	<9.1				
Cesium 137(pCi/L)			01/19/93	<15.5				
			08/27/93	<18.9				
			08/27/93	<13				
					08/27/93	<9.62		
					08/27/93	<11.8		
			08/27/93	<4.2				
					08/27/93	<4.2		
			11/12/93	<12.8				
			11/12/93	<4.1				
					11/16/93	<18		
					11/16/93	<5.5		
			01/20/94	<8.83				
			01/20/94	<6.4				
					01/22/94	<13.5		
					01/22/94	<7.7		
			06/10/94	<13.9				
					06/10/94	<12.3		
			06/10/94	<7.9				
					06/10/94	<7.1		
			12/22/94	<12.5				
			12/22/94	<10				
Cobalt 57(pCi/L)			06/10/94	<3.6				
					06/10/94	<3.5		
			12/22/94	<4.9				
Cobalt 60(pCi/L)			08/27/93	<2.2				
					08/27/93	<2.7		
			11/12/93	<4.2				
					11/16/93	<7		
			01/20/94	<7.5				
					01/22/94	<7.5		
			06/10/94	<7.1				
					06/10/94	<6.1		
			12/22/94	<9.1				
Europium 152(pCi/L)			08/27/93	<6.1				
					08/27/93	<6.9		
Europium 154(pCi/L)			08/27/93	<3.3				

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
					08/27/93	<4.5		
Europium 155(pCi/L)			08/27/93	<6.9				
					08/27/93	<6.8		
Lead 210(pCi/L)			08/27/93	<95				
					08/27/93	<93		
Lead 212(pCi/L)			01/19/93	48.06				
			08/27/93	<18.6				
			08/27/93	<13.1				
					08/27/93	<13.2		
					08/27/93	<123		
			08/27/93	<9.5				
					08/27/93	<9.1		
			11/12/93	<15.2				
			11/12/93	<8				
					11/16/93	<11		
			01/20/94	<12				
					01/22/94	<13		
			06/10/94	<13				
					06/10/94	<12		
			12/22/94	<16				
Lead 214(pCi/L)			08/27/93	<10				
					08/27/93	<10		
			11/12/93	<9.2				
					11/16/93	<13		
			01/20/94	14.9				
					01/22/94	96.3		
			06/10/94	<13				
					06/10/94	<15		
			12/22/94	<20				
Manganese 54(pCi/L)			08/27/93	<6.6				
					08/27/93	<2		
Potassium 40(pCi/L)			08/27/93	<222				
			08/27/93	<225				
					08/27/93	<179		
					08/27/93	<166		
			08/27/93	<65				
					08/27/93	<66		
			11/12/93	<219				
			11/12/93	<58				
					11/16/93	<94		
			01/20/94	<100				
					01/22/94	<100		
			06/10/94	<97				
					06/10/94	<110		
			12/22/94	<130				
Radium 226(pCi/L)			08/27/93	<94				
					08/27/93	<84		
			11/12/93	<90				
					11/16/93	<150		
			01/20/94	<150				
					01/22/94	<160		
			06/10/94	<140				
					06/10/94	<140		
			12/22/94	<180				
Ruthenium 106(pCi/L)			08/27/93	<27				
					08/27/93	<32		
Silver 110m(pCi/L)			08/27/93	<4.9				
					08/27/93	<5.1		

Table H-1. Continued.

Analyte	Date	W-827-05	Date	W-829-06	Date	W-829-08	Date	W-829-15
Thallium 208(pCi/L)			08/27/93	<5.8				
					08/27/93	<5.3		
			11/12/93	<5.5				
					11/16/93	<8.6		
			01/20/94	<7.8				
					01/22/94	<8.9		
			06/10/94	<9.7				
					06/10/94	<9.9		
			12/22/94	<13				
Thorium 234(pCi/L)			08/27/93	<110				
					08/27/93	<100		
			11/12/93	<79				
					11/16/93	<120		
			01/20/94	<130				
					01/22/94	<130		
			06/10/94	<120				
					06/10/94	<130		
Uranium 235 and Uranium 236(pCi/L)			08/27/93	<6				
					08/27/93	<5.5		
			11/12/93	<21				
					11/16/93	<33		
			01/20/94	<34				
					01/22/94	<37		
			06/10/94	<35				
					06/10/94	<33		
			12/22/94	<47				

Table H-2. Historic soil monitoring data.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
EPA Method 8010 (mg/kg)					
1,1,1-Trichloroethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
1,1,2,2-Tetrachloroethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
1,1,2-Trichloroethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
1,1-Dichloroethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
1,1-Dichloroethene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
1,2-Dichlorobenzene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
1,2-Dichloroethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
1,2-Dichloroethene (total)	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
1,2-Dichloropropane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
1,3-Dichlorobenzene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
1,4-Dichlorobenzene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
2-Chloroethylvinylether	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Bromodichloromethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Bromoform	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
Bromomethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Carbon tetrachloride	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Chlorobenzene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Chloroethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Chloroform	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Chloromethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
cis-1,2-Dichloroethene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
cis-1,3-Dichloropropene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Dibromochloromethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Dichlorodifluoromethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Freon 113	322.5	12/13/90	0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
Methylene chloride	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Tetrachloroethene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	0.00059
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
trans-1,2-Dichloroethene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
trans-1,3-Dichloropropene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Trichloroethene	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	0.0021
	50			7/13/94	< 0.0005
	50.3			7/13/94	0.00061
	41			7/13/94	0.0013
	59.7			7/13/94	0.0086
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	0.00082
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	260.6			8/2/94	< 0.005
Trichlorofluoromethane	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	0.0007
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
Vinyl chloride	322.5	12/13/90	< 0.0002		
	332.8	12/19/90	< 0.0002		
	366.8	12/19/90	< 0.0002		
	388.8	12/19/90	< 0.0002		
	0			7/11/94	< 0.0005
	10.6			7/12/94	< 0.0005
	19			7/12/94	< 0.0005
	26.3			7/12/94	< 0.0005
	36.2			7/13/94	< 0.0005
	50			7/13/94	< 0.0005
	50.3			7/13/94	< 0.0005
	41			7/13/94	< 0.0005
	59.7			7/13/94	< 0.0005
	71.5			7/14/94	< 0.0005
	80.3			7/14/94	< 0.0005
	92.3			7/14/94	< 0.0005
	106			7/14/94	< 0.0005
	115.3			7/18/94	< 0.0005
	124.6			7/18/94	< 0.0005
	134.4			7/18/94	< 0.0005
	144.5			7/26/94	< 0.0005
	156.7			7/26/94	< 0.0005
	164.7			7/27/94	< 0.0005
	176			7/27/94	< 0.0005
	185.2			7/27/94	< 0.0005
	194.7			7/27/94	< 0.0005
	206.2			7/28/94	< 0.0005
	217			7/28/94	< 0.0005
	226			7/28/94	< 0.0005
	235			8/1/94	< 0.0005
	245.5			8/1/94	< 0.0005
	255.3			8/2/94	< 0.0005
	265			8/2/94	< 0.0005
	276.8			8/2/94	< 0.0005
	284.3			8/2/94	< 0.0005
	334.6			8/3/94	< 0.0005
	339			8/3/94	< 0.0005
	295			8/3/94	< 0.0005
	304.2			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	317.3			8/3/94	< 0.0005
	325.7			8/3/94	< 0.0005
	378.7			8/4/94	< 0.0005
	352.7			8/4/94	< 0.0005

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	352.7			8/4/94	< 0.0005
	359			8/4/94	< 0.0005
	364.8			8/4/94	< 0.0005
	384			8/8/94	< 0.0005
	394			8/8/94	< 0.0005
	404.8			8/8/94	< 0.0005
	260.6			8/2/94	< 0.005
<u>High Explosives (mg/kg)</u>					
HMX	0			7/11/94	< 0.2
	10.4			7/12/94	< 0.2
	24.5			7/12/94	< 0.2
	34.7			7/12/94	< 0.2
	55			7/13/94	< 0.2
	45.5			7/13/94	< 0.2
	63.2			7/13/94	< 0.2
	63.5			7/13/94	< 0.2
	75.5			7/14/94	< 0.2
	87.3			7/14/94	< 0.2
	96.8			7/14/94	< 0.2
	102			7/14/94	< 0.2
	112			7/14/94	< 0.2
	119.4			7/18/94	< 0.2
	130.2			7/18/94	< 0.2
	141			7/26/94	< 0.2
	141.3			7/26/94	< 0.2
	150.2			7/26/94	< 0.2
	162.4			7/26/94	< 0.2
	170.7			7/27/94	< 0.2
	181.5			7/27/94	< 0.2
	190.3			7/27/94	< 0.2
	210			7/28/94	< 0.2
	219.9			7/28/94	< 0.2
	229.7			7/28/94	< 0.2
	241			8/1/94	< 0.2
	249.1			8/1/94	< 0.2
	260.6			8/2/94	< 0.2
	273.7			8/2/94	< 0.2
	280.4			8/2/94	< 0.2
	290			8/2/94	< 0.2
	299.2			8/3/94	< 0.2
	309			8/3/94	< 0.2
	320.8			8/3/94	< 0.2
	329			8/3/94	< 0.2
	345.5			8/4/94	< 0.2
	356.7			8/4/94	< 0.2
	369.8			8/4/94	< 0.2

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	369.8			8/4/94	< 0.2
	379			8/8/94	< 0.2
	389			8/8/94	< 0.2
	399			8/8/94	< 0.2
	411.5			8/8/94	< 0.2
RDX	0			7/11/94	< 0.15
	10.4			7/12/94	< 0.15
	24.5			7/12/94	< 0.15
	34.7			7/12/94	< 0.15
	55			7/13/94	< 0.15
	45.5			7/13/94	< 0.15
	63.2			7/13/94	< 0.15
	63.5			7/13/94	< 0.15
	75.5			7/14/94	< 0.15
	87.3			7/14/94	< 0.15
	96.8			7/14/94	< 0.15
	102			7/14/94	< 0.15
	112			7/14/94	< 0.15
	119.4			7/18/94	< 0.15
	130.2			7/18/94	< 0.15
	141			7/26/94	< 0.15
	141.3			7/26/94	< 0.15
	150.2			7/26/94	< 0.15
	162.4			7/26/94	< 0.15
	170.7			7/27/94	< 0.15
	181.5			7/27/94	< 0.15
	190.3			7/27/94	< 0.15
	210			7/28/94	< 0.15
	219.9			7/28/94	< 0.15
	229.7			7/28/94	< 0.15
	241			8/1/94	< 0.15
	249.1			8/1/94	< 0.15
	260.6			8/2/94	< 0.15
	273.7			8/2/94	< 0.15
	280.4			8/2/94	< 0.15
	290			8/2/94	< 0.15
	299.2			8/3/94	< 0.15
	309			8/3/94	< 0.15
	320.8			8/3/94	< 0.15
	329			8/3/94	< 0.15
	345.5			8/4/94	< 0.15
	356.7			8/4/94	< 0.15
	369.8			8/4/94	< 0.15
	369.8			8/4/94	< 0.15
	379			8/8/94	< 0.15
	389			8/8/94	< 0.15
	399			8/8/94	< 0.15
	411.5			8/8/94	< 0.15

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
TNT	0			7/11/94	< 0.1
	10.4			7/12/94	< 0.1
	24.5			7/12/94	< 0.1
	34.7			7/12/94	< 0.1
	55			7/13/94	< 0.1
	45.5			7/13/94	< 0.1
	63.2			7/13/94	< 0.1
	63.5			7/13/94	< 0.1
	75.5			7/14/94	< 0.1
	87.3			7/14/94	< 0.1
	96.8			7/14/94	< 0.1
	102			7/14/94	< 0.1
	112			7/14/94	< 0.1
	119.4			7/18/94	< 0.1
	130.2			7/18/94	< 0.1
	141			7/26/94	< 0.1
	141.3			7/26/94	< 0.1
	150.2			7/26/94	< 0.1
	162.4			7/26/94	< 0.1
	170.7			7/27/94	< 0.1
	181.5			7/27/94	< 0.1
	190.3			7/27/94	< 0.1
	210			7/28/94	< 0.1
	219.9			7/28/94	< 0.1
	229.7			7/28/94	< 0.1
	241			8/1/94	< 0.1
	249.1			8/1/94	< 0.1
	260.6			8/2/94	< 0.1
	273.7			8/2/94	< 0.1
	280.4			8/2/94	< 0.1
	290			8/2/94	< 0.1
	299.2			8/3/94	< 0.1
	309			8/3/94	< 0.1
	320.8			8/3/94	< 0.1
	329			8/3/94	< 0.1
	345.5			8/4/94	< 0.1
	356.7			8/4/94	< 0.1
	369.8			8/4/94	< 0.1
	369.8			8/4/94	< 0.1
	379			8/8/94	< 0.1
	389			8/8/94	< 0.1
	399			8/8/94	< 0.1
	411.5			8/8/94	< 0.1
Total Metals (mg/kg)					
Antimony	0			7/11/94	< 1
	1.3			7/12/94	< 1
Arsenic	0			7/11/94	1.2

Table H-2. Continued.

Analyte	Depth (ft)	Date	W-827-05	Date	W-829-15
	1.3			7/12/94	0.5
Barium	0			7/11/94	65
	1.3			7/12/94	48
Beryllium	0			7/11/94	< 0.5
	1.3			7/12/94	< 0.5
Cadmium	0			7/11/94	< 1
	1.3			7/12/94	< 1
	1.3			7/12/94	< 0.1
Chromium	0			7/11/94	14
	1.3			7/12/94	19
Cobalt	0			7/11/94	8
	1.3			7/12/94	7.2
Copper	0			7/11/94	13
	1.3			7/12/94	15
Lead	0			7/11/94	< 10
	1.3			7/12/94	< 10
Mercury	0			7/11/94	< 0.05
	1.3			7/12/94	< 0.05
Molybdenum	0			7/11/94	< 5
	1.3			7/12/94	< 5
Nickel	0			7/11/94	11
	1.3			7/12/94	13
Selenium	0			7/11/94	< 0.5
	1.3			7/12/94	< 0.5
Silver	0			7/11/94	< 2.5
	1.3			7/12/94	< 2.5
Thallium	0			7/11/94	< 1
	1.3			7/12/94	< 1
Vanadium	0			7/11/94	73
	1.3			7/12/94	69
Zinc	0			7/11/94	43
	1.3			7/12/94	38

Appendix I

Appendix I.

Site 300 Safety Plan

UCRL-21172 rev 1

Site Safety Plan
for
Site 300 Environmental
Restoration Division Operations

December 1994

Environmental Protection Department
Environmental Restoration Division

Site Safety Plan
for
Site 300
Environmental Restoration Division Operations

Review and Concurrence:

Yee Ping Chong
Yee Ping Chong
ES&H Team 1 Leader
Hazards Control Department

12/12/94
Date

John J Greci
John Greci
Site 300 Environmental Restoration Division
Safety Officer

8/19/94
Date

Milt Grissom
Milt Grissom
Site 300 Resident Manager

12/6/94
Date

Albert L Lamarre
Albert Lamarre
Site 300 Environmental Restoration Section Leader

12/21/94
Date

Robert W Bauer for
William McConachie
Environmental Restoration Division Leader

12/27/94
Date

Michael J Taffet
Michael J. Taffet
Site 300 Environmental Restoration Division
Operational Safety Coordinator

8.19.94
Date

Contents

Figures

Table

Foreword

Various Department of Energy Orders incorporate by reference, health and safety regulations promulgated by the Occupational Safety and Health Administration (OSHA). One of the OSHA regulations, 29 CFR 1910.120, *Hazardous Waste Operations and Emergency Response*, requires that site safety plans are written for activities such as those covered by work plans for Site 300 environmental investigations.

Based upon available data, this Site Safety Plan (Plan) for environmental restoration has been prepared specifically for the Lawrence Livermore National Laboratory Site 300, located approximately 15 miles east of Livermore, California. As additional facts, monitoring data, or analytical data on hazards are provided, this Plan may need to be modified. It is the responsibility of the Environmental Restoration Safety Officer (ERSO), with the assistance of Hazards Control, to evaluate data which may impact health and safety during these activities and to modify the Plan as appropriate. This Plan is not "cast-in-concrete." The ERSO shall have the authority, with the concurrence of Hazards Control, to institute any change to maintain health and safety protection for workers at Site 300.

1. Emergency Contacts and Telephone Numbers

Local Contact for All Emergencies

LLNL Site 300 Emergency Response Dispatch	911

Hazardous Materials Information

ENSR	(800) 922-4636
Toxline	(301) 496-1131
CHEMTREC (24-hour, emergency only)	(800) 424-9300
ORNL, Toxicology Information Response Center	(615) 576-1743
Site 300 ES&H Team 1	(510) 423-5286
or	(510) 423-5287
Hazardous Waste Management Division	(510) 423-5909

LLNL Contacts

Albert Lamarre, Site 300 Section Leader, Environmental Restoration Division (ERD)	(510) 422-0757
John Greci, ERD Safety Officer	(510) 423-5043
or Beeper	(510) 423-7705-05240
Jon Cunningham, ERD Safety Officer–Backup	(510) 423-5043
or beeper	(510) 423-7705-05159
Michael J. Taffet, ERD Operational Safety Coordinator	(510) 422-6114
or beeper	(510) 423-7705-05468
Rebecca Failor, Section Leader, Environmental Monitoring and Analysis Division (EMAD)	(510) 422-5316
Dan Benjamin, ES&H Team 1 Site 300 Leader	(510) 423-5286
Yee Ping Chong, ES&H Team 1 Leader	(510) 423-2521

Contractor Contacts

Robert Ferry, Weiss Associates	(510) 422-9984
Parris Baker, PC Exploration	(916) 783-9733
Ken Johnson, Ground Water Technology	(510) 671-2387

Larry Bradley, Line Locator Service .... (415) 851-2996

Site 300 Organizational Structure

Figure 1 is an organizational chart for the Environmental Restoration Division Site 300 Section.

Standard Procedures for Reporting Emergencies (Phone 911)

When calling for assistance in an emergency situation, the following information should be provided:

1. Name of person making call.
2. Telephone number and location of person making call.
3. Name of person(s) exposed or injured and location.
4. Nature of emergency and type of exposure, when appropriate.
5. Actions already taken.
6. Stay on phone until released by the emergency dispatcher.

Never hang up first when calling for emergency assistance. Wait for the Dispatch operator to finish all questions.

The designated emergency number "911" should be clearly displayed at all Site 300 Environmental Restoration activity locations.

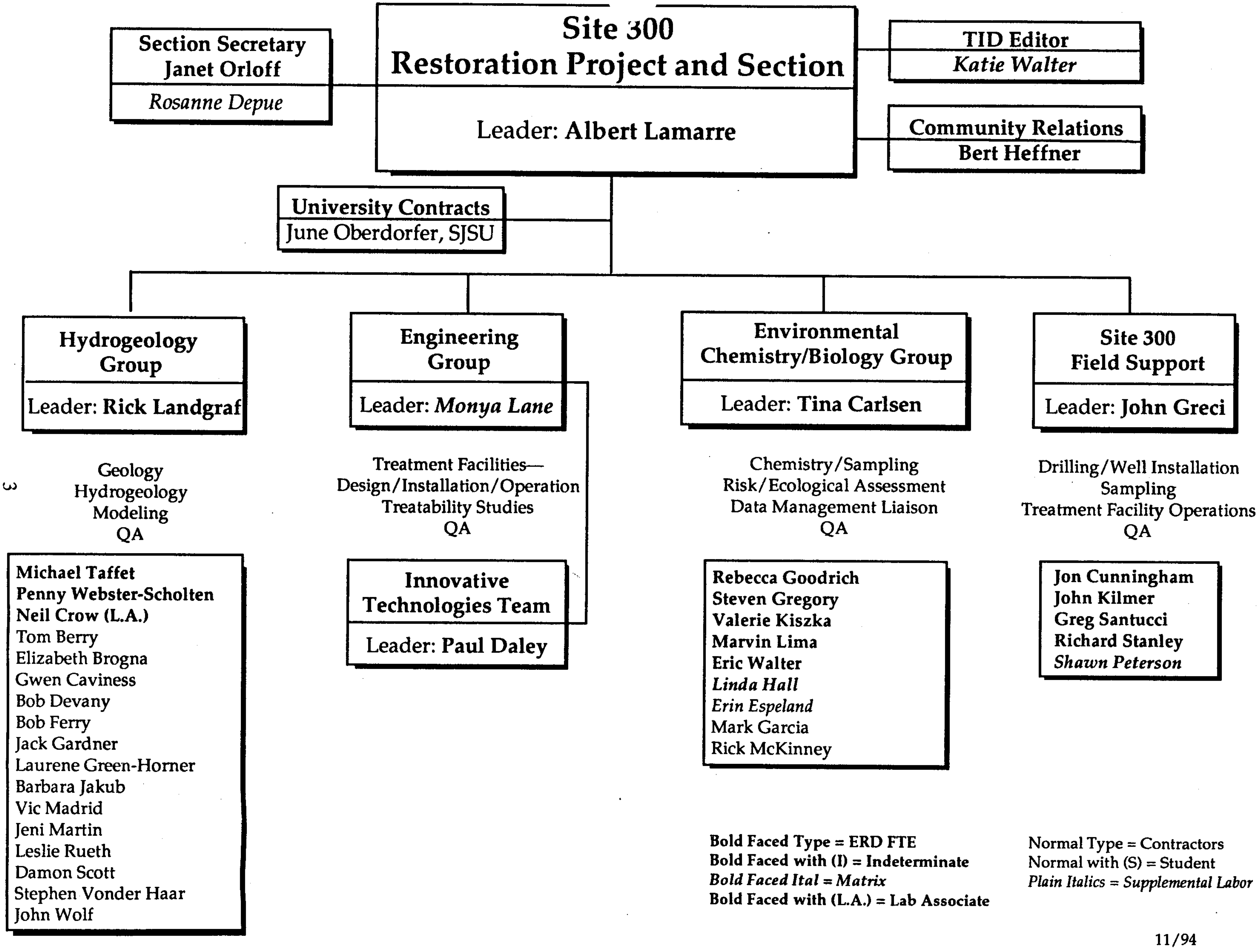


Figure 1. Site 300 Environmental Restoration Division Section organizational chart.

2. General Information and Policies

The safety policy of Lawrence Livermore National Laboratory (LLNL) is to take every reasonable precaution in the performance of work to protect the environment and the health and safety of employees and the public, and to prevent property damage. Protection from hazardous agents is provided by limiting exposures of people, releases to the environment, and contamination of property to levels that are as low as reasonably achievable (ALARA). It is the intent of this Plan to supply the broad outline for completing environmental investigations within ALARA guidelines. It should be clearly understood that it may not be possible to determine actual working conditions in advance of the work. Therefore, planning must allow the opportunity to provide a range of protection based upon actual working conditions.

All personnel working on this project must follow the policies set forth in this Plan, as well as LLNL and the U.S. Department of Energy (DOE) policies, procedures, and instructions. Of special value is LLNL's *Health and Safety Manual* (Hazards Control Dept., 1989) and the *Site 300 Safety Procedures* (July 5, 1989, Revision). Unique field operations at the site require Operational Safety Procedures (OSPs) if the safety procedures specific to such operations are beyond the scope of this plan. An example of an OSP is provided in Appendix H. OSPs are displayed at the sites they pertain to. OSPs are also on file at Building 843 and the ERD Division Office in Trailer 5475 at the LLNL Main Site. Subcontractors not working directly under ERD supervision must develop their own health and safety procedures, which may be modeled on those provided by LLNL. Procedures developed by subcontractors must be reviewed and approved by the Environmental Restoration Safety Officer (ERSO) prior to the initiation of work.

Each time the term ERSO is used, it must be understood that either the ERSO or his designee should take responsibility or complete the action.

Employees are required to bring to the attention of their supervisor any unsafe or hazardous condition observed as they carry out their responsibilities. The supervisor shall then promptly inform the ERSO and Hazards Control so that the situation can be corrected and personnel can be advised of an improved procedure. It is clearly impossible to anticipate all specific safety and health hazards beforehand; therefore, all personnel must exercise common sense and good judgment in their approach to a given situation. "Personnel Training" in Section 9.0 of this document describes how to prepare individuals to recognize hazards. This document incorporates appropriate rules, guidelines, and recommended work practices contained in previously published material. All personnel shall follow the safety and health procedures set forth below.

Due to the relatively large size of LLNL Site 300, the different types of activities underway, and the potential hazards present, periodic review of site-specific safety issues and potential controls, shall be made by Hazards Control ES&H Team 1 upon request by ERD. Hazards Control ES&H Team 1 shall determine whether an OSP, an addendum to an existing OSP, or additional safety documentation is necessary for individual ERD operations in different portions of Site 300. If modifications to this Plan need to be made, these changes may be issued as attachments to this document.

3. Summary of Background Information

LLNL operates the Experimental Test Site, Site 300 in support of the Defense and Non-defense programs. Site 300 is located in the eastern Altamont Hills about 15 miles southeast of LLNL and 65 miles southeast of San Francisco. Site 300 is an explosives (HE) and materials testing site in support of weapons development for DOE. Figure 2 is a map of Site 300 indicating the locations of various environmental restoration activities.

Since 1982, LLNL has conducted a series of investigations to identify areas of soil, rock, and ground water contamination. The goal has been to remediate those areas to bring Site 300 into compliance with Federal, State, and local regulations. Details of planned work are presented in the *LLNL Site 300 Environmental Restoration Work Plan* (Lamarre, January 1989). LLNL also conducts routine, quarterly ground water monitoring around two closed Resource Conservation and Recovery Act (RCRA) landfills. Details of this monitoring program are presented in the *LLNL Site 300 Groundwater Monitoring Program* quarterly reports. These documents are available in the Environmental Restoration activities office in Building 843 at Site 300.

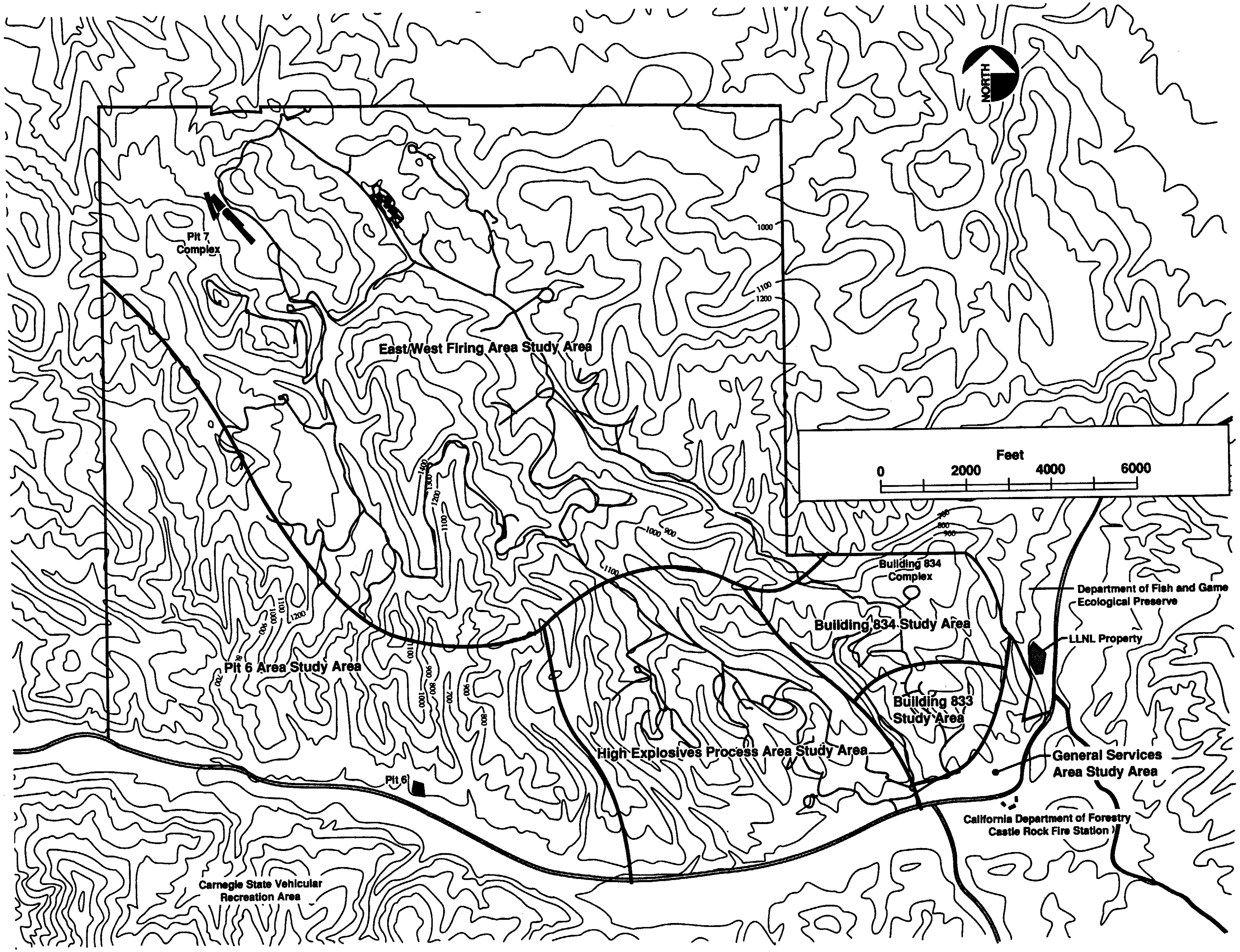
Analytical results from various sampling activities and quarterly ground water monitoring have identified the presence of various contaminants. Volatile organic compounds (VOCs) have been found at varying concentrations in the parts-per-billion (ppb) range, with trichloroethylene levels approaching parts-per-million (ppm) concentrations. Tritium in ground water has been found at concentrations of up to 600,000 picocuries per liter (pCi/L) and 16,000,000 pCi/L in soil moisture. HE compounds have been identified at concentrations of up to 350 ppb in ground water and 18 ppm in soil. Depleted uranium in soil has been found at concentrations of up to 141 pCi/gram (g). Lead and beryllium have been confirmed at very low parts-per-million concentrations. Although of environmental concern, these concentrations are typically well below workplace permissible exposure limits.

On the basis of analytical results, the substances present at Site 300 include:

- Trichloroethylene (TCE).
- Beryllium.
- Lead and other metals.
- Natural and depleted uranium.
- HMX [octahydro-1,3,5,7-tetranitro-tetrazocine].
- RDX [hexahydro-1,3,5-trinitro-1,3,5-triazine.
- Tetrachloroethylene (PCE).
- Tritium.
- Diesel and gasoline hydrocarbons.

Other work activities may pose potential exposures or problems due to:

- Fuel hydrocarbons:
  Benzene
  Gasoline
  Toluene
  Xylene.
- Heavy equipment.
- Noise.
- Nuisance dust.
- Snake bite.
- Temperature extremes:
  Heat stress
  Cold exposure.
- Unknown materials previously disposed of in landfills.
- Valley Fever.



92-1224 rush Taffet

Figure 2. Locations of the Environmental Restoration Division study areas at LLNL Site 300.

This plan addresses health and safety issues related to the various tasks and phases for the environmental work planned and ongoing at Site 300. Technical issues and specifications for scope of work are presented in the specific LLNL quality assurance, work, and closure plans. These should be reviewed by the ERSO and Hazards Control ES&H Team 1 in conjunction with performing their responsibilities and to assist in presenting pertinent health and safety concerns to site workers.

4. Organization, Responsibilities, and Authority

Key personnel are listed below by name and title with address and telephone number.

Milton Grissom
Site 300 Manager
P.O. Box 808, L-871
Lawrence Livermore National Laboratory
Livermore, CA 94551
(510) 423-1396

Albert L. Lamarre
Site 300 Environmental Restoration Section Leader
P.O. Box 808, L-619
Lawrence Livermore National Laboratory
Livermore, CA 94551
(510) 422-0757

John Greci
Site 300 Environmental Restoration Safety Officer
P.O. Box 808, L-843
Lawrence Livermore National Laboratory
Livermore, CA 94551
(510) 423-5043

Yee Ping Chong
ES&H Team 1 Leader
P.O. Box 808, L-323
Lawrence Livermore National Laboratory
Livermore, CA 94551
(510) 423-2521

Dan Benjamin
Hazards Control ES&H Leader for Site 300
P.O. Box 808, L-871
Lawrence Livermore National Laboratory
Livermore, CA 94551
(510) 423-5286

4.1. Responsibilities of the ERSO

Health and safety activities are important during all phases of any project. The degree of implementation of the activities or services is related to the perceived risk. With the concurrence of ES&H Team 1, the ERSO shall have the responsibility to determine health and safety needs for this project and the authority to ensure that appropriate measures are taken. The ERSO shall immediately inform the Project Leader and Hazards Control of any health and safety conditions that may adversely affect the project.

With the assistance of ES&H Team 1, the ERSO is specifically required to take the following actions:

- Ensure that Site 300 orientation and safety multimedia presentations are viewed.
- Require specific health and safety precautions prior to work site entry by LLNL and subcontractor personnel. Ensure that personnel adhere to requirements of this Plan.
- Require any LLNL or subcontractor employee to obtain immediate medical attention in case of an injury or illness.
- Deny access to LLNL and/or subcontractor personnel to the site or any work site in the event that to enter such an area would pose an unacceptable risk.
- Order the immediate evacuations of LLNL and/or subcontractor employees from any work site when conditions posing an unacceptable risk arise through the course of work.
- Permit visitors (i.e., anyone other than an LLNL or subcontractor employee) at work sites only at the direction of and with the permission of responsible LLNL personnel. Visitors shall abide by the requirements specified in this Plan and, when possible, shall be restricted from areas of potential exposure to hazardous substances.
- Establish an area in the support zone upwind of the work zone for personnel to assemble in the event of an evacuation of the work zone. Monitor LLNL and subcontractor operations for the existence of hazardous conditions. Monitor personnel for signs of exposure, heat stress, fatigue, etc.
- Evaluate the results of the monitoring program and determine impacts on future operations.
- Ensure that environmental and personnel monitoring operations are ongoing and in accordance with technical specifications, procedures, and project instructions.
- Monitor site conditions during operations to determine whether any changes in work zones or personnel protection are required.
- Ensure that proper personal protective equipment (PPE) is available and worn by on-site personnel. Ensure that PPE and other equipment is maintained and properly stored.
- Ensure that work areas are kept clean in order to reduce the potential for general safety hazards.
- Ensure that personnel receive the required medical surveillance specified in individual Site 300 Site Safety and Health Plans.
- Know emergency procedures and contacts.
- Conduct work site safety briefings that cover the contents of this Plan, safe work practices, PPE use, and emergency procedures.
- Assure that all required training (including on-the-job training) is completed and documented.

- Assist subcontractor personnel supervisor in conducting site safety briefings that cover the contents of this plan.
- Ensure that subcontractor personnel do not get within intraline distance of explosives storage facilities or explosives operations.

4.2. Responsibilities of LLNL and Subcontractor Personnel

All LLNL and subcontractor personnel assigned to this project are responsible for following this Plan, for using safe work practices, and for wearing the PPE specified by the ERSO or by the site-specific plan. Project personnel shall report hazards and unsafe conditions and practices to the ERSO or the subcontractor supervisor and Hazards Control. All Federal, State, and local health and safety regulations must be complied with by project personnel.

All site personnel shall comply with the requirements of this plan and cooperate with project management in its implementation. It is the responsibility of all site personnel to immediately report any of the following to the site safety officer:

- All accidents or injuries.
- Unsafe or malfunctioning equipment.
- Any symptoms or signs of chemical exposure.
- Unexpected or uncontrolled releases of chemicals.
- Unauthorized personnel entry onto site.
- Any changes in the site conditions which might adversely affect the health and safety of personnel.

The Site 300 Manager has ultimate authority over all operations at Site 300 including assessment and cleanup activities at hazardous waste sites.

The Leader of ES&H Team 1 (Hazards Control Department) provides an interface between the members of Team 1 and the Environmental Restoration Division. The health and safety professionals and technicians assigned to Team 1 provide support and technical services to the ERSO as requested, and as required by LLNL policy.

The ERSO will review and update this Plan as necessary to ensure that the listed organizational structure reflects the current status of the waste site operations.

The ERSO shall inform all contractors of emergency response procedures and known hazards of the hazardous waste operations site prior to site entry.

This Plan and supporting health and safety documents must be available for review and use by the ERSO and his/her designee. All documents are available in the Building 843 office.

5. Medical Surveillance Program

The purpose of the medical surveillance screening program is to assess the health status of personnel prior to work, to monitor personnel for evidence of adverse health effects during and after completion of the project, and to determine their suitability for future work assignments of this type. All personnel who will be working on this project must undergo a medical evaluation before participating in these operations. If the ERSO determines that significant exposure to hazardous materials may have occurred during these operations, a follow-up medical exam shall be conducted on the potentially exposed individuals.

Baseline and periodic health assessments for project personnel shall be consistent with LLNL requirements and Occupational Safety and Health Administration (OSHA) regulations prescribed in 29 CFR 1910, especially those in 1910.120.

At a minimum, the examination should include:

- Medical and work histories.
- Physical examination.
- Vision test.
- Urinalysis.
- Blood chemistry panel and complete blood count.
- Pulmonary function tests and respirator use clearance.
- Valley Fever immunity skin test.

Optional tests include:

- X-rays.
- Electrocardiograms.
- Bioassays.

Due to the low risk of acute exposure, additional medical monitoring specific to this project is not anticipated.

If an individual has completed an occupational medical exam within the past 12 months, the examining physician may determine that another complete exam is unnecessary.

LLNL will provide medical surveillance for all LLNL employees who may be exposed to chemical hazards while working on the project. Contractors will provide medical surveillance for their employees who may be exposed to hazards, as specified in their contracts with LLNL and DOE.

Additionally, a medical surveillance program will be provided by the LLNL Environmental Restoration Division for its employees who are covered by one or more of the following items:

- All employees who are or may be exposed to airborne levels of hazardous substances above OSHA-Permissible Exposure Limits (PEL) or in the absence of PEL other published exposure limits, without regard to the use of respirators, for 30 days or more per year.

- All those who use a respirator are required to comply with the provisions of 29 CFR 1910.134 Respiratory Protection which requires medical qualification for issuance of a respirator.
- All employees who are injured due to overexposure from an emergency incident involving hazardous substances or health hazards.
- Employees who wear a respirator for more than 30 days per year shall be included in the medical surveillance program for the substances that require use of the respirator.

Employees covered by the medical surveillance program are given medical examinations and consultations at the following frequency:

- Prior to Assignment.
- Annually, unless attending physician extends the interval up to two years or decreases the interval as medically necessary.
- At termination of employment or reassignment to another area where employee will not be under medical surveillance, if the employee has not had an examination within the last six months.
- As soon as possible after development of signs or symptoms indicating overexposure to hazardous substances or health hazards or if the employee has been injured or exposed to hazardous substances above PEL or other published exposure levels.

Medical examinations include a medical and work history (the history shall be updated annually) with special emphasis on: symptoms related to the handling of hazardous substances; health hazards of these substances; and fitness for duty including the ability to wear any required PPE under the conditions (i.e., temperature extremes) that may be expected at the work site. All medical examinations and procedures shall be performed by or under the supervision of the licensed physician.

The attending physician will be provided with the following information by the site safety officer or supervisor in conjunction with Hazards Control.

- A description of the employee's duties as they relate to employee's exposures.
- The employee's exposure levels or anticipated exposure levels.
- A description of any personal protective equipment used or to be used. If respirators are to be worn, then information will be provided concerning the type, anticipated periods of use, workloads, etc. as required by 29 CFR 1910.134.
- Where feasible, information from previous medical examinations of the employee which is not readily available to the examining physician.

LLNL Health Services will provide each covered employee with a written opinion from the attending physician containing the following:

- A summary of the results of the examination.

- An opinion as to whether the employee has any detected medical conditions which would place the employee at increased risk of impairment of the employee's health from work in hazardous waste site operations or from the use of respirators. The written opinion shall not reveal specific findings or diagnosis unrelated to occupational exposure.
- Any recommended limitations upon the employee's assigned work.
- Any medical conditions which require further medical examination or treatment.

An accurate record of the medical surveillance shall be retained in accordance with 29 CFR 1910.20. The record shall include at least the following items:

- Employee's name and social security number.
- Physician's written opinion, recommended limitations, and results of examinations and tests.
- Any employee medical complaints related the exposure to hazardous substances.
- A copy of the information provided to the examining physician by the employer with the exception of the standard and its appendices.

6. Hazard Evaluation

There are potential hazards associated with the environmental investigations of the LLNL Site 300. These include:

Chemical Hazards

- Benzene.
- Beryllium.
- Diesel.
- Gasoline.
- HMX.
- Hydrochloric acid.
- Lead.
- Nitric acid.
- RDX.
- Tetrachloroethylene.
- Trichloroethylene.
- Toluene.
- Tritium.
- Natural uranium.
- Depleted uranium.
- Xylene.

Biological Hazards

- Snake bite.
- Valley Fever.

Physical Hazards

- Heavy equipment (drill rigs, air compressors, backhoe, crane).
- Excavations.
- Overhead power lines.
- Underground utilities.
- Confined space entry.
- Fire and explosion.
- Electrical hazards.
- Noise.
- Heat stress.
- Frostbite and hypothermia.

General Safety Hazards

Hazards to Non-Project Personnel

6.1. Chemical Hazards

The chemicals or substances listed above as chemical hazards may enter the body through inhalation, skin absorption, or ingestion. These chemicals may enter by more than one route, may cause damage at the point of entry, or may cause organ damage after being metabolized.

The operations on some hazardous waste sites may involve the use of hazardous substances which are not hazardous wastes, but are used in the operations or stored onsite. For example, hydrogen peroxide (50%), which is a strong oxidizer, may be used at some sites to treat ground water contamination.

The ERSO and/or site supervisor will ensure that all site employees are trained in accordance with 29 CFR 1910.1200, Hazard Communication and the LLNL *Health and Safety Manual* Supplement 7.02 (formerly 1.02).

Exposure limits, detectable limits, and other references to airborne chemical concentrations given below are for vapors or particulates in air. Concentrations encountered in soil and ground water are generally several orders of magnitude lower than the limits specified here. Therefore, even direct contact with soil and ground water and exposure to associated contaminants is unlikely to produce acute exposures.

The respiratory hazards associated with work activities are exposure to vapors, gases, and/or particulates such as dusts during drilling, well installation, tank excavation, decontamination, and other operations. It is not anticipated that exposure levels in excess of recommended permissible exposure limits (PELs) or threshold limit values (TLVs) will be encountered. However, precautions must be taken to minimize dust generation during work activities that contain toxic compounds such as lead or beryllium. This may require spraying the work area with water in sufficient amounts to control dust. The open-air environment at the site should provide adequate ventilation to reduce potential respiratory hazards to very low or negligible levels. Dermal hazards result from direct contact of solids, liquids, or vapors with the skin. Since the potential for vapor contact is low, dermal hazards from vapors are expected to be negligible. Direct contact with contaminated soil and ground water in the field would not generally result in dermal effects. Acids used for sample preservation are corrosive to the skin, eyes, and respiratory tract. Therefore, good hygienic practices, and the fact that these chemicals may be absorbed through the skin or are corrosive, warrant protecting the skin.

Based upon previous experience at this site, it is anticipated that direct skin contact is unlikely to occur if protective clothing and/or protective equipment is used as specified in Section 8.

To prevent ingestion of hazardous or toxic materials, workers should wash their hands prior to eating, drinking, smoking, or using restroom facilities.

Abbreviations and acronyms relating to exposure limits are provided in Appendix A. Readily available Material Safety Data Sheets (MSDSs) are provided in Appendix B.

Benzene

Odor: Aromatic; odor threshold, approximately 4.7 ppm.

Fire Potential: Dangerous; when exposed to heat or flame can react vigorously with oxidizing materials.

Flammable Limits—LFL 1.3%, UFL 7.9%.
Explosive Limits—LEL 1.3%, UEL 7.1%.

Exposure: Irritating to eyes, nose, and throat. Suspected human carcinogen. <u>Symptoms:</u> dizziness, excitation, pallor, followed by flushing, weakness, headache, breathlessness, chest constriction, loss of consciousness.

OSHA PEL: TWA, 1 ppm; STEL, 5 ppm.

ACGIH TLV* : TWA, 10 ppm; IDLH, 2,000 ppm.

Beryllium

Fire Potential: Combustible; poisonous gases may be produced in fire.

Exposure: Dust is extremely toxic when inhaled. Symptoms: coughing, shortness of breath, acute or chronic lung disease. Any dramatic, unexplained weight loss should be considered as first indication of beryllium disease.

OSHA PEL: TWA, 2 $\mu g/m^3$; Ceiling, 5 $\mu g/m^3$; Max. peak, 25 $\mu g/m^3$ for 30 min.

ACGIH TLV: TWA, 2 $\mu g/m^3$; suspect human carcinogen.

Note: DOE is considering lowering PEL for beryllium to 1.0 $\mu g/m^3$.

Diesel

Odor: Characteristic of petroleum distillate.

Fire Potential: Flash point 185°C; fire hazard greater if liquid temperature exceeds 85°F; may explode if pressure is used to empty drums.

Exposure: Irritating to eyes, nose, and throat; central nervous system depressant if inhaled. Symptoms: headache, dizziness, loss of appetite, weakness, and loss of coordination. Incomplete combustion produces carbon monoxide; toxic fumes may accumulate.

ACGIH TLV: Not established. Reduce exposure to lowest feasible level.

Gasoline

Odor: Characteristic of gasoline; odor threshold, 0.25 ppm.

Fire Potential: Flammable; flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area.

Flammable Limits—LFL 1.4%, UFL 7.4%.

Exposure: Irritating to eyes, nose, and throat. Symptoms: irritation of mucous membranes, dizziness, headache, incoordination, anesthesia, coma.

ACGIH TLV: TWA, 300 ppm; STEL, 500 ppm.

HMX (*Synonym:* Octogen)

Fire Potential: Moderate, by spontaneous chemical reaction.

Exposure: Irritation of eyes and respiratory tract.

DOT-Hazard: Cannot be shipped in a dry state.

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* TLV may be reduced to 0.1 ppm.

Hydrochloric Acid

Odor: Pungent; sharp.

Fire Potential: Not flammable. Flammable hydrogen gas may be formed on contact with metals.

Exposure: Irritating to eyes, nose, and throat. Severe skin irritant.

OSHA PEL: Ceiling, 5 ppm for 15 min.

ACGIH TLV[*] **:** Ceiling, 5 ppm.

IDLH: 100 ppm.

Lead

Exposure: Lead is a potent, systemic poison. Chronic exposure may result in damage to blood-forming, nervous, urinary, and reproductive systems.

OSHA PEL:	TWA, 50 $\mu g/m^3$.
ACGIH TLV:	TWA, 0.15 mg/m^3.

Nitric Acid

Odor: Acrid; sweet to acrid.

Fire Potential: Not flammable; may cause fire on contact with combustibles. Flammable hydrogen gas may be formed on contact with metals.

Exposure: Corrosive to tissue, may cause severe burns to eyes and skin. Irritating to eyes, nose, and throat. May also release toxic oxides of nitrogen (NO_x) gas.

OSHA PEL:	TWA, 2 ppm; STEL, 4 ppm.
ACGIH TLV:	TWA, 2 ppm; STEL, 4 ppm.

IDLH: 100 ppm.

RDX (*Synonym:* Cyclonite)

Fire Potential: Moderate, by spontaneous chemical reaction.

Exposure: Irritation of eyes and respiratory tract. May be absorbed through intact human skin.

ACGIH TLV:	TWA, 1.5 mg/m^3.

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[*] TLV may be reduced to 50 $\mu g/m^3$.

Tetrachloroethylene (PCE)

Odor: Ether-like; odor threshold, 5 ppm.

Fire Potential: Nonflammable.

Exposure: Irritating to eyes, nose, and throat. Symptoms: affects central nervous system, causes anesthesia and peripheral neuropathy. Potent liver toxin. This compound may be carcinogenic.

OSHA PEL: TWA, 100 ppm; ceiling, 200 ppm; max. peak, 300 ppm; 5 minutes in any 3 hours.

ACGIH TLV: TWA, 50 ppm; STEL, 200 ppm.

IDLH: 500 ppm.

Trichloroethylene (TCE)

Odor: Sweet; odor threshold, 50 ppm.

Fire Potential: Low fire hazard.

Flammable Limits—LFL 8%, UFL 10.5%.
Explosive Limits—LEL 12.5%, UEL 90%.

Exposure: Irritating to eyes, nose, and throat. Symptoms: nausea, blurred vision, disturbance of central nervous system. Liver toxin. This compound may be carcinogenic.

OSHA PEL: TWA, 100 ppm; ceiling, 200 ppm; max. peak, 300 ppm; 5 min. in any 2 hours.

ACGIH TLV: TWA, 50 ppm; STEL, 200 ppm.

IDLH: 1,000 ppm.

Toluene

Odor: Sweet, pungent, benzene-like odor; odor threshold, 0.17 to 2.1 ppm.

Fire Potential: Flammable liquid ignitable under almost all normal temperature conditions.

Flammable Limits—LFL 1.2%, UFL 7.1%.
Explosive Limits—LEL 1.2%, UEL 7.1%.

Exposure: Irritating to eyes, nose, throat. Symptoms: dizziness, headache, anesthesia.

OSHA PEL: TWA, 200 ppm; ceiling, 300 ppm; max. peak, 500 ppm, 10 min.

ACGIH TLV: TWA, 100 ppm; STEL, 150 ppm.

IDLH: 2,000 ppm.

Tritium (^3H)

Half-Life:

Physical: 12.3 years.
Biological: ~10 days (range: 4–18) total body for HTO.

Special Chemical and Biological Characteristics: Not selectively concentrated in any organ. Metabolized as H_2O. Tritium is assumed to be readily and completely absorbed by the body and to be distributed evenly throughout the body. Tritium is a potential human carcinogen.

Principal Human Metabolic and Dosimetric Parameters:

f_1 (Absorption fraction) = 1.0.
ALI [Allowable life-time intake] (μCi) = 8.1×10^4 (HTO).
DAC (Derived air concentration) (μCi/cm^3) = 2.2×10^7 (HTO).

Natural and Depleted Uranium

Specific Activity: Natural uranium, 6.6×10^{-7} Ci/g.
Depleted uranium, 3.3×10^{-7} Ci/g.

Sources: Natural uranium is approximately 99.3% uranium-238 by weight.
Depleted uranium is approximately 99.7% uranium-238 by weight.

Principal human metabolic parameters.

Compound	Inhalation class[a]	ALI (ingestion) (μCi)	ALI (inhalation) (μCi)	DAC (μCi/cm^3)	DAC (mg/m^3)	Dominant hazard	ACGHI TLV-TWA (mg/m^3)
Nitrates, fluorides, chlorides, sulfates, acetate, UO_3	D	1.4×10^1	1.4	6.0×10^{-10}	0.8	Chemical	0.2
UF_4, U_3O_8, UO_2	W	1.4×10^1	0.81	$.0 \times 10^{-10}$	0.4	Chemical/ radiological	0.2
High-fired uranium oxides and metals	Y	1.9×10^2	5.4×10^{-2}	2.0×10^{-11}	0.03	Chemical/ radiological	0.2

[a] Inhalation Classes D, W, and Y are as defined in ICRP Publication 30 Part 1, *Annals of the ICRP, Limits for Intakes of Radionuclides by Workers,* 1979, Vol. 2, No. 3/4. In general, Class D compounds are cleared from the lungs in a matter of days, Class W compounds are cleared from the lungs within a few weeks, and Class Y compounds may take years to be cleared from the lungs.

Exposure: Uranium presents both chemical and radiological hazards, depending upon the amount of enrichment and the chemical form. In the case of depleted or natural uranium, relatively soluble compounds present heavy metal toxicity hazards similar to lead. The organ of concern for chemical hazards is the kidney. Relatively insoluble compounds (e.g., high-fired uranium oxides or metals) present chemical/radiological hazards. The organs of concern in this case are the lungs, bone, and kidney.

Xylene

Odor: Like benzene; odor threshold, 0.05 ppm.

Fire Potential: Material is flammable and can form explosive mixtures with air.

Flammable Limits	Meta xylene—(XLM):	LFL 1.1%, UFL 6.4%.
	Ortho xylene—(XLO):	LFL 1.1%, UFL 7.0%.
	Para xylene—(XLP):	LFL 1.1%, UFL 6.6%.

Exposure: Irritating to eyes, nose, and throat. Can readily be absorbed through intact skin. Symptoms: headache, dizziness, and coughing.

OSHA PEL: TWA, 100 ppm.

ACGIH TLV: TWA, 100 ppm; STEL, 150 ppm.

IDLH: 10,000 ppm.

6.2. Biological Hazards

Snake Bite

Rattlesnakes inhabit Site 300 and steps should be taken to protect workers through the use of snake chaps and high-top boots when appropriate. Anyone who has been bitten should be removed to a safe area. The individual should be kept calm. Notify the Emergency Dispatch **(911)** immediately. Although a tourniquet can be used to restrict flow of venom to the heart, care must be exercised so that the limb is not damaged from the pressure exerted by the tourniquet. Arrangements have been established with Tracy Hospital for such an emergency to ensure the availability of antivenom serum.

Valley Fever

All persons who work at or visit Site 300 may be exposed to Valley Fever, a respiratory infection common throughout the San Joaquin Valley. All persons who work at Site 300 will be informed of their possible exposure to Valley Fever. Supervisors are responsible for ensuring that before assigning or hiring an employee to work at Site 300, for a short term or indefinitely, that the employee is referred to Health Services. Health Services will brief the individual regarding Valley Fever. Immunity or lack of immunity can be determined by a simple skin test. Health Services will inform the employee of the health risks associated with Valley Fever and a Site 300 assignment.

6.3. Physical Hazards

Working conditions at the site involve potential exposure to the physical hazards discussed below.

Mechanical Motions and Actions

A wide variety of mechanical motions and actions may present hazards to personnel. These can include the movement of rotating members, include the movement of rotating members, reciprocating arms, moving belts, meshing gears, cutting teeth, and any part that may cause impact or shear. These different types of hazardous mechanical motions and actions are basic in varying combinations to nearly all machines.

Any machine part, function, or process which may cause injury shall be either guarded (physical barriers which prevent access to danger areas) or safeguarded (provided with devices which inhibit machine operation, to mitigate or eliminate danger areas).

Machine operators shall be trained in the proper use of equipment and associated guards/safeguards to protect themselves and others from machine-related hazards.

Machine operators shall wear protective clothing or personal protective equipment as necessary whenever engineering controls are not available or are not fully capable of protecting personnel. Protective equipment selected shall be:

- Appropriate for the particular hazards,
- Maintained in good condition,
- Properly stored when not in use to prevent damage or loss, and
- Kept clean, fully functional, and sanitary.

As a minimum, safety shoes and safety glasses shall be worn by all personnel operating or working within close proximity of heavy machinery or equipment. When there is a potential for head injury, hard hats shall be worn.

Excavations

Falls into open excavations and/or side wall collapse while personnel are inside the excavation are the major dangers. To minimize these hazards, excavations shall be barricaded and the walls properly sloped or shored according to OSHA requirements before personnel are allowed to enter the excavation. Personnel not directly involved in excavation activities shall remain at least ten feet away from the edge of an excavation. Excavated materials shall be kept at least 2 feet from the edge of the excavation. Plan work in or near excavations carefully and in consultation with the ERSO about protective measures and equipment use. Individuals shall be properly trained prior to initiating work activities. See Appendix C for information on trench and excavation safety.

Overhead Power Lines

No equipment shall be operated closer than 15 feet in any direction to overhead power lines.

Underground Utilities

Site 300 Plant Engineering shall be notified of site activities in order to locate and mark any potentially hazardous underground utilities. In addition, an underground utilities-locating firm will identify buried lines before drilling starts.

Confined Space Entry

Although no confined space entries are currently anticipated, employees will be trained in what types of areas might be confined spaces. When entry into a confined space is necessary, Hazards Control will be contacted to obtain a confined space entry permit. The procedures required by the LLNL *Health and Safety Manual* Supplement 26.14, "Working in Confined Spaces," 29 CFR 1910.146–Permit Confined Spaces, and the ANSI Z117.89, "Safety Requirements for Confined Spaces" shall be followed.

Fire and Explosion

It is not anticipated that ground water and soil contaminants exist at concentrations sufficient to create fire and explosion hazards during routine drilling and sampling activities. Operating heavy equipment could create such hazards associated with fuel tank rupture. Such emergencies shall be handled as described in Section 7. Removal of underground tanks could create a potential for fire and explosion. Tank removal safety procedures will be addressed in an addendum to this Plan.

Several chemicals which may be encountered at the site during tank excavation are highly flammable liquids and present explosion hazards if vapors are present at levels above the lower explosive limit (LEL).

Chemical name	LEL (% by volume in air)
Benzene	1.3
Gasoline	1.4
Xylenes	1.0

To minimize explosion hazards, all tanks and piping will be emptied and flushed prior to excavation. All piping will be disconnected from tanks, the tanks emptied, and dry ice applied to the tank interior to displace oxygen prior to tank removal at the rate of 10 pounds of dry ice per 1,000 gallons of tank volume. The atmosphere inside the tank will be monitored with an oxygen meter prior to removal. At least one 20-pound dry chemical fire extinguisher will be available. No hot work or open flames will be allowed in the work area. It is anticipated that concentrations of these substances in fill or soil materials will be sufficiently low so as not to present a fire hazard. However, the detection of fuel products in fill and soil materials shall be cause to initiate the evaluation for vapors with respect to fire, explosion, and personnel exposure.

Electrical Hazards

Ignorance of basic electrical principles and misuse of electrical equipment contribute to many accidents. The human body's resistance can be drastically reduced by working with wet tools, in wet or damp locations, inside tanks and boilers, or around metal piping or other grounding materials. Other factors affecting the severity of electrical injuries include the path of the current through the body, the vital organs in that path, and the duration of the current through the body.

There are many ways an employee can come into contact with energized circuits. The most common of these are contact with exposed live parts and overhead or buried power lines. When working in the vicinity of live electrical parts, such as exposed wires, switches, or contacts, the parts must be guarded from contact by effective insulation or other means. Whenever possible, work on electrical equipment shall be performed in a totally de-energized state using lock and tag techniques as stipulated by Health and Safety Manual, Supplement 26.13, "General Lockout and Tagout Procedure." If a cognizant supervisor determines that work must be performed on energized equipment, the controls in Health and Safety Manual, Table 23-3 "Safety Controls Necessary for Electrical Work" must be followed. If that is not possible, the circuit must be de-energized and visibly grounded.

Pertinent information on electrical safety can be found in Appendix D.

Noise

Noise exposure is primarily associated with heavy equipment, steam cleaning, and air compressors. Based upon previous experience, it is not anticipated that the noise levels will be of concern. Ear protection is provided for all field personnel and its use is encouraged when appropriate. Personnel may also experience impulse noise of up to 140 dB from explosives tests. Sound levels shall be monitored during the above operations and any other operation that generates hazardous noise levels.

Heat Stress

Heat stress is associated with exposure to high temperatures, wearing protective clothing, and physical exertion. Temperatures at the site can exceed 100°F on occasion. Drinking water is available on site and appropriate breaks shall be taken if temperature and levels of personal protection so dictate. Work should be conducted under umbrellas when appropriate to provide shade. Based upon previous experience and work performed at this site, it is not anticipated that heat stress will be a major concern when proper precautions are taken.

Personnel will inform the ERSO of any symptoms of heat stress, such as:

- Weakness and fatigue.
- Dizziness.
- Nausea.
- Headache.

The ERSO will be alert to signs of heat stress in site personnel and increase the frequency of breaks and fluid consumption as necessary. First aid care may require the following:

- Move victim to a cool environment.
- Loosen victim's clothing.
- If fainting seems likely, have the victim lie down with feet elevated 8 to 12 inches.
- Provide victim with sips of cool water or electrolyte drink such as Gatorade.
- In extreme cases, obtain medical assistance as quickly as possible.

The ERSO shall determine the schedule of work and rest periods based on the temperatures at the work site. If there is any question as to the potential for heat stress during operations, the ERSO shall contact the ES&H Team 1 industrial hygienist for any evaluation of the operational hazards and controls, including measurement of wet bulb globe temperature index.

Frostbite and Hypothermia

In cold environments, the body's metabolic rate must increase to maintain its thermal balance. Shivering increases the metabolic heat production and yet the feet, face, and hands still may feel cold. This often creates confusion for the exposed individual because he/she may be warmly clothed. Frostbite results from exposure to severe cold. It is more likely to occur when the wind is blowing. The nose, cheeks, ears, toes, and fingers are the body parts most frequently frostbitten. Hypothermia is the general cooling of the entire body.

To prevent frostbite and hypothermia:

- Dress warmly in cotton and wool clothing.
- Initiate work/rest regimens that ensure adequate protection from the cold.
- Drink hot fluids such coffee, tea, or soup.

Finally, obtain medical assistance when there is any doubt regarding the severity of exposure.

Explosives Hazards

Personnel could sustain injuries from blast fragments or heat should they be exposed to an accidental explosion or should they pick up an explosive. Personnel shall be made aware of the hazards involved with handling explosives. They shall remain at least at intraline distance from all explosives storage and operating facilities. Offices shall be at least at the inhabited building distance from all explosives storage and operating facilities.

6.4. General Safety Hazards

Other possible safety hazards include the potential for slipping, falling, head trauma, material handling, insect bites, etc. All personnel working on the project shall wear appropriate personal protective equipment (EPA Level D), including eye protection, head protection (hard hat), and steel-toed boots as required by the ERSO. First aid is available onsite to take care of any minor injuries. The Emergency Dispatch **(911)** shall be contacted to deal with emergency situations more serious than cuts or scrapes.

6.5. Hazards to Non-Project Personnel

Potential risks to project personnel have been outlined above. Potential risks to other persons on the site who are not working on this project are exposure to vapors, gases, and chemicals in soil or ground water and the physical hazards associated with heavy equipment.

Air monitoring may be conducted to minimize the possibility of public and personnel exposure to vapors and gases. These procedures are described in Section 8. Due to the open air environment at the site and the fact that the work zone will be barricaded, the risk to the public and laboratory personnel is expected to be negligible.

7. Emergency Actions

7.1. Planning

Prior to entering a work site, the ERSO shall, with coordination with Hazards Control, plan escape routes and discuss them with personnel conducting project work. Initial planning includes establishing the best means for evacuation from the site in case of a catastrophe (e.g., explosion, tank rupture, fire, etc.).

7.2. Emergency Services

An installed and tested system must be in place for rapid and clear distress communications, preferably voice, from all personnel to the ERSO. The ERSO shall ensure that all personnel know how to communicate with the LLNL Emergency Dispatch at 911. In the event of an emergency, the ERSO shall notify the LLNL Fire Department. The ERSO shall also notify Hazards Control and Health Services, who will, if necessary, notify appropriate off-site emergency response units, and provide adequate and clear directions to reach LLNL work sites from the location of those units. All personnel shall have adequate and clear directions and accessible personnel transportation to local emergency services.

7.3. Evacuation

If evacuation is necessary, all personnel will proceed to a predetermined location in the support zone upwind of the site. The predetermined evacuation route and assembly location will be specified in the site-specific plan for each site. The ERSO is responsible for establishing evacuation procedures.

7.4. Emergency Evacuation From Contaminated Areas

Any person requiring medical attention shall be evacuated promptly from any contaminated area. However, personnel should not enter an area to attempt a rescue if their own lives would also be threatened because of inadequate personal protection (e.g., oxygen deficient atmosphere and no self-contained breathing apparatus). The ERSO or Hazards Control shall be responsible for contacting the LLNL Emergency Dispatch at **911** to evacuate any person from a work area and for providing special decontamination treatment or procedures for any injured person. Evacuation shall occur if personal protective equipment fails.

7.5. First Aid

Qualified personnel may give first aid and stabilize any employee needing assistance. A qualified person is defined as a person who has received training in the first-aid assistance to be provided. Life-support techniques such as CPR and treatment of life-threatening problems such as bleeding, airway maintenance, and shock shall be given top priority. Professional medical assistance shall be obtained at the earliest possible opportunity.

If assistance beyond first aid is required, phone the LLNL Emergency Dispatch at 911.

A first aid kit and ANSI approved portable eyewash shall be maintained in the support zone. For example, when drilling, these items should be kept in a clean location adjacent to or on the drill rig.

Emergency first aid procedures for acids and organic compounds include:

Eyes	Flush eyes immediately with fresh water for at least 15 minutes while holding the eyelids open. Call LLNL Emergency Dispatch at **911** immediately.
Skin	Wash skin thoroughly with soap and water. Immediately remove all contaminated clothing. See a doctor. Launder contaminated clothing.
Inhalation	Move exposed person to fresh air. If breathing has stopped, apply artificial respiration. Call LLNL Emergency Dispatch at **911** immediately.
Ingestion	If swallowed, **DO NOT** make person vomit. Call LLNL Emergency Dispatch at **911** immediately.

7.6. Fire

Immediately call the LLNL Emergency Dispatch at **911,** then quickly assess whether the fire can be contained using a fire extinguisher.

7.7. Hazardous Materials Spill

A small spill is one in which no one is injured or contaminated; the identity of the spilled substances is known; the substance spilled is commonly handled by Site 300 personnel and they are familiar with and prepared for its hazards; the spill is confined to the immediate release area and is not threatening other work areas or the environment; and the spill will take two people less than one hour to clean up. Refer to the appropriate MSDS for special instructions regarding cleanup or spills. Soil that has absorbed the liquid shall be dug up and placed in a drum, along with material used for confinement and absorbence.

If the spill does not meet all of the preceding criteria, then it is classed as a "large spill". For large spills, call LLNL Emergency Dispatch at **911** and the Hazardous Waste Management Division of the Environmental Protection Department **(3-5509)**.

7.8. Guidelines

If any emergency involving actual or suspected personal injury occurs, the ERSO shall follow these steps:

- Render first aid if necessary. Decontaminate affected personnel.
- Obtain paramedic service or ambulance transport to local hospital by calling the LLNL Emergency Dispatch at **911**. This procedure shall be followed even if there is no visible injury.
- Notify Hazards Control of the incident (**3-5286**).
- Other personnel on site shall be evacuated to a safe distance until the ERSO and Hazards Control determine that it is safe for work to resume.
- At the earliest time practicable, the ERSO shall contact the Project Leader or his designee, giving details of the incident, and the steps taken to prevent its recurrence.
- A written report of the incident must be forwarded to the Project Leader, or his designee, within 24 hours following the incident.

Subsequent reporting shall be completed according to LLNL's Incident Analysis and Reporting requirements.

8. Personal Protective Apparel and Equipment

Suggested item specifications and descriptions are for information only. Equivalent items may be purchased.

8.1. Personnel Protection

The nature of this work is such that several potentially hazardous conditions could be encountered. It is not possible to determine all protective requirements in advance of actual conditions. Where feasible, engineering controls in accordance with 29 CFR 1910, Subpart G and work practices are used to prevent exposure of employees to hazardous substances above their PEL or other published exposure limit (if no PEL exists). However, when not feasible or not required, a reasonable combination of engineering controls, work practices and Personnel Protection Equipment (PPE) will be used. PPE selection is made to protect the employees from hazards or potential hazards at the site in accordance with 29 CFR 1910, Subpart I, Personal Protective Equipment.

The proper use and selection of PPE includes consideration of at least the following items:

- Proper use (i.e., donning and doffing).
- Equipment limitations (i.e., reduced dexterity, vapor versus liquid contact, hazardous substance and concentration, temperature).
- Anticipated duration of use.
- Maintenance and storage requirements.
- Decontamination and disposal.
- Inspection procedures.
- Heat and cold stress, activity levels, and other medical considerations.
- Employee training and fitting of equipment.

Employee rotation shall not be used in order to achieve compliance of employee exposures to hazardous substances with PELs.

Detailed descriptions of the four generic levels of personal protection are provided in Appendix G of this document. Depending upon circumstances and the hazards present at a given site, some of the items recommended for a given level may be modified as appropriate. The level of protection is selected based upon characteristics of hazardous substances (i.e., concentration, toxicity, entry routes, warning properties, etc.) and the potential for exposure to air, from splashes of or from immersion in liquids, or other direct contact with hazardous substances.

Level D consists of a work uniform which provides minimal protection and essentially no protection against chemical hazards. It is used when no inhalation hazard is present nor anticipated to occur during the operations and skin contact with hazardous substances by immersion or splash is not anticipated.

Level C consists of Level D items with the addition of splash protection apparel and a full-face or half-mask air purifying respirator. Level C is used when full protection from skin contact is not required; the concentration(s) and type(s) of airborne substance(s) are known; cartridges or filters for removal of contaminants are available and all of the criteria for using air purifying respirators are satisfied.

Level B consists of a work uniform which provides the highest level of respiratory protection, but a lesser level of skin protection. It includes a self-contained breathing apparatus (SCBA) or a pressure-demand supplied air respirator with escape SCBA. Also included are the clothing components of Level C.

Level A is selected when the greatest level of skin, respiratory, and eye protection are required. It includes the respiratory protection apparatus of Level B. It also includes a totally encapsulating protective suit.

Items specified below are intended to allow the ERSO and Hazards Control the latitude to provide a range of protection based upon actual working conditions. The ERSO shall ensure that all workers have the following items available for their use. Items actually used should be based upon work activities and potential hazards. Some may never be used if the severity of the hazard(s) do not require the protection provided by the item.

- **Gloves**
  Inner, surgical type (latex disposable)
  Outer, chemical protective (neoprene or nitrile).
- **Protective clothing**
  Cotton, regular, washable coveralls
  AND Tyvek, regular, disposable, zippered coveralls.
- **Footwear**
  Chemical protective boots (low-temperature vinyl), steel-toed
  OR safety shoes worn with protective rubber overshoes.
- **Eye protection**
  Safety glasses with side-shields
  OR indirectly vented chemical goggles
  OR single unit plastic “specs” with side-shields for visitors.
- **Hard hat with attachable face shield (optional)**
- **Hearing protection**
  Muffs and/or earplugs.
- **Respirators**

  NIOSH-approved full face mask air-purifying respirator equipped with filters and/or cartridges appropriate for the hazard.

  OR NIOSH-approved half-mask air-purifying respirator equipped with filters and/or cartridges appropriate for the hazard.

  A Hazards Assessment form shall be completed by the ES&H Team 1 industrial hygienist for each operation and shall specify the correct respirator for the job being performed.

Conventional eyeglass frames cannot be used with full-face mask respirators because of interference with the face seal. Special eyeglasses can be mounted inside the face mask; however, this results in a time delay for obtaining prescription lenses.

Personnel who wear respirators will be trained in their proper usage, have a current medical examination, and have been fit tested within the past 12 months. Facial hair which interferes with respirator seal must be removed prior to respirator usage (29 CFR 1910.134 and LLNL Respiratory Protection Program).

The ERSO shall specify which employees are required to wear the items listed above.

If unanticipated conditions are encountered which require additional personnel protection, the ERSO shall ensure that appropriate additional personal protective apparel and equipment is in use prior to continuing activities under those conditions.

8.2. Apparel Decontamination

The ERSO may establish at least one safety apparel decontamination station at the work site in the contamination reduction zone. At a minimum, soap or detergent, rinse water, towels, wash pans, and brushes for scrubbing boots shall be available. Decontamination will consist of removing any potentially contaminated soil from boots by washing with soap and water or removing boot covers in the contamination reduction zone upon exit from the work zone. Wash water will be available in a basin suitable for standing in while washing boots. This wash water will be contained, sampled, and disposed of properly based upon analytical results.

The location of the decontamination process will be selected to minimize the exposure of uncontaminated employees and equipment to the contaminated employees and equipment. The ERSO will monitor decontamination procedures to determine their effectiveness.

In the event that permeable clothing should become wetted with hazardous substances, the employee will immediately remove the clothing and proceed to shower.

When protective clothing or equipment is sent to commercial cleaning establishments for decontamination, those establishments will be informed of the potentially harmful effects of exposures to the hazardous substances present.

If additional personal protective equipment is used, such as Polytyvek suits and chemical-resistant gloves, they will be removed in the contamination reduction zone upon leaving the work zone. Should this equipment be required, it will be decontaminated or disposed of properly.

8.3. Equipment Decontamination

Soils remaining on tools, sampling equipment, or heavy equipment will be removed by steam cleaning. Water used for decontamination will be containerized and disposed of properly based upon analytical results. The ERSO shall ensure that decontamination procedures used are adequate to remove contamination for the specific project undertaken.

8.4. Personnel Decontamination and Personal Hygiene

Personnel may be subject to skin or eye irritation from contaminants. Individuals engaged in work activities where there is a potential for exposure to toxic/hazardous materials should shower at the end of the work shift.

Where regular showers and change rooms are needed for decontamination outside of contaminated areas, they will meet the requirements of 29 CFR 1910.141, "SANITATION." Protective equipment and/or clothing will not be removed from change rooms by unauthorized personnel.

Personnel shall wash hands and face prior to any break, rest period, or lunch. Sanitary washing facilities shall be provided at, or near, the work area.

8.5. Fire Protection

Call fire station II at **3-5201** to coordinate plans and procedures that ensure that fire and explosion hazards are minimized. If suitable water supplies are unavailable or where water use may be inappropriate. The fire safety engineer shall specify appropriate fire protection equipment.

8.6. Monitoring Program

The monitoring program shall be sufficient to determine

- Airborne concentrations of hazardous chemical/radiological substances.
- Combustible gas and oxygen levels.
- Surface contamination of work areas.
- Contamination of personal protective apparel and equipment.
- Personnel contamination.
- Suitability of release of equipment and material to unrestricted areas.

Monitoring Equipment

The ERSO shall ensure that sufficient quantities of all necessary monitoring equipment are available before work is started. Other equipment deemed necessary by the ERSO and Hazards Control prior to work initiation shall be obtained at his direction. The ERSO shall also ensure that these instruments are used only by persons who have had prior experience and training with their care, calibration, and operation and who know their limitations. No work shall be done unless the necessary instrumentation is available and in proper working order.

To assist in evaluating potential hazards, as appropriate, the ERSO and Hazards Control shall use any of the following equipment as deemed necessary:

- Radiation detection equipment/monitors.
- Combustible gas/oxygen meter.

- Photoionization detector (PID).
- Organic Vapor Analyzer (OVA).
- Hand pump (e.g., Draeger) with colorimetric detector tubes for specific compounds.
- Constant flow personnel air sampling pumps which can be calibrated to appropriate volumetric air flow rates to collect airborne samples consistent with NIOSH requirements. Other items needed, at a minimum, include: tubing, filter cassette holders, charcoal tubes, filters, and calibration equipment.
- Passive Chemical Dosimeters (i.e., 3M Organic Vapor Monitor, Draeger Direct-Reading Diffusion Tubes).
- Other Real-Time Monitoring Instruments (i.e., hydrogen sulfide, carbon monoxide, etc.).

Initial Monitoring

When appropriate, a preliminary survey of existing air quality conditions is performed by a qualified person to determine the presence of any of the following prior to commencement of operations:

- Any immediately dangerous to life and health (IDLH) condition (airborne hazardous substance, NIOSH).
- Potential exposure to hazardous substance in excess of PEL or other published exposure limit as appropriate.
- Exposure to radioactive substance in excess of established dose limits.
- Exposure to other dangerous conditions (i.e., flammable atmospheres or oxygen deficiency).

The site is initially inspected for visual signs of dangerous conditions and surveyed with a PID or OVA and a combustible gas/oxygen meter prior to initiation of any work activities to establish baseline levels for use in proper selection of engineering controls, safe work practices, and PPE. Where radiation is anticipated, the site is also surveyed with radiation detection equipment. The use of engineering controls, safe work practices, and PPE shall be reviewed by the ES&H Team 1 industrial hygienist prior to the start of work.

If the presence of other hazardous substances not detectable with above equipment is anticipated (hydrogen sulfide, carbon monoxide, etc.) the appropriate monitoring equipment will be used to survey the site (i.e., Draeger detector tubes, substance specified monitors, etc.).

The preliminary survey will focus on the following areas:

- The contamination reduction zone upwind from drilling activities, excavation, and other work activities.
- Locations where workers may assemble or congregate.
- Confined spaces or areas where gases may be trapped.

Periodic Monitoring

Periodic monitoring of on-site ambient contaminant concentrations of VOCs in the immediate vicinity of work activities will be performed using a PID or OVA. The ERSO in consultation with Hazards Control will compare monitoring results with OSHA standards to ensure that proper protection is provided.

Periodic monitoring is performed whenever there is a possibility that an IDLH condition or explosive atmosphere has developed or when an indication that exposure may be in excess of the PEL or other published exposure limits (or when conditions that may affect airborne concentrations, change). When the following situations exist, additional monitoring shall be considered:

- Initiation of work in a different portion of the site.
- New contaminants are known to be present.
- Initiation of a different type of operation.
- Workers handling leaking containers or working in areas with obvious contamination.

High Risk Employees

The employees who are most likely to be exposed to hazardous substances above the PEL or other published exposure limits will be monitored first. If they are being exposed to levels above the PEL or other applicable standards such as ACGIH–TLVs, DOE standards, or NIOSH standards, then monitoring will be performed to establish which other employees, if any, may also be exposed above PEL.

Where work activities may generate dust contaminated with beryllium or lead, it may be necessary to use a calibrated sampling pump to collect an airborne sample of particulate on a filter. When this is done, samples should be analyzed by an American Industrial Hygiene Association (AIHA) accredited laboratory according to NIOSH procedures.

PID or OVA results are not compound specific and provide a reading of total organic vapors that the instrument is able to detect.

When benzene is a potential exposure problem, a direct readout of benzene vapor concentrations should be obtained using an instrument similar to a Draeger pump with a colorimetric detector tube specific for benzene. Personnel protection, respirator selection, monitoring, and operational protocols and procedures must be developed for work atmospheres where benzene concentrations are greater than the PEL of 1 ppm. In addition to instantaneous or grab samples, integrated samples using personal sampling pumps shall also be taken.

Perimeter Monitoring

Under certain circumstances, it may be necessary to conduct perimeter monitoring to evaluate emissions resulting from work covered by this Plan. If such monitoring is conducted and results are higher than baseline levels of any contaminant, immediate steps will be taken to determine the cause, make changes to site operations, evacuate unprotected personnel and the public, if necessary, and notify regulatory agency contact personnel. Specific protocols to be implemented shall be determined by the ERSO and the Project Leader for each incident.

9. Personnel Training

Individuals assigned to this project shall undergo training to:

- Ensure that the health and safety of all employees and the public is maintained.
- Safeguard the health and safety of all employees and the public by complying with all laws, rules, and regulations.
- Increase the ability of employees to react responsibly to emergencies and to handle emergency situations in a safe manner.
- Increase the ability of employees to complete their work in an efficient and timely manner.

9.1. Hazardous Waste Operations and Emergency Response Requirements

All personnel working on hazardous waste cleanup sites at LLNL who may be exposed to physical and chemical hazards shall attend 40 hours of health and safety training, 24 hours of on-the-job field training under supervision, as specified in OSHA 29 CFR 1910.120. Personnel shall be trained prior to their participation in field activities and written certificates are to be issued upon successful completion of that training. The Section Leader, ERSO, and contractor supervisors are required to complete an additional 8 hours of "Hazardous Waste Management" training. All site personnel are required to complete 8 hours of "Refresher" training annually.

Trainers shall be qualified to instruct employees about the subject matter that is being presented in training. Instructors shall have completed a training program for the subjects that they are expected to teach or have academic credentials and instructional experience for teaching the subjects.

The above requirements address minimal training needs and additional training will be provided as deemed appropriate.

At a minimum, worker training should address the following topics:

- Names of Personnel and Alternates Responsible for Site Health and Safety.
- Medical Surveillance and Signs of Overexposure.
- Elements of this Site Safety Plan.
- Program Discussion/Regulatory Overview.
- Training Rationale.
- Chemical and Physical Hazards.
- Toxicology.

- Environmental Planning.
    - Hazards Analysis.
    - Work Plan.
    - Site-Safety Plan.
- Characterization and Site Activities.
- Site Control.
- Personal Protective Equipment.
    - Clothing.
    - Respirators and Fit Testing.
- Air Monitoring.
- Decontamination.
- Emergencies.
- Site Operations.
- Hazardous Substance Identification.
- Hazard Communication Program.

9.2. Work Site-Specific Topics

All site personnel (LLNL employees and contractors) shall attend a site-specific training session, arranged by the ERSO, that addresses:

- Exposure to hazardous substances anticipated to be present at the site.
- Prohibited practices.
- Emergency procedures.
- Site-specific safety requirements.
- General safety requirements.

In addition, all personnel shall view the Site 300 orientation film.

Emergency Procedures and Services

Refer to page 1 of this document for emergency telephone numbers and Section 7 of this document for emergency procedures. Discussion during training sessions should include as required:

- LLNL Emergency Dispatch **(911)**.
- Signals, alarms, and hazard signs.
- Evacuation routes and procedures.
- Assembly points.

- Buddy system.
- Communications.
- Fire protection.
- Barricades and scaffolds.
- Emergency equipment.
- First aid and contaminated wounds.
- Spills.

General Safety Requirements

All project work shall be performed in a manner consistent with providing a safe work environment. General safety guidelines are:

- Wear appropriate protective clothing for the job, including, but not limited to, hard hat, work clothing, shoes, and eye protection.
- Decontaminate known sources of contamination (such as gloves and boots) at the location established for decontamination. Remove equipment only after decontamination or containerization on site.
- Keep track of weather conditions and wind direction when working outside.
- Plan activities thoroughly ahead of time: enter work sites only to get to a designated point for a specific purpose and then only by a designated route.
- Always observe the buddy system: never enter or exit alone, and never work alone in an isolated area.
- Always maintain contact with the ERSO and Corporation Yard (Building 843). The Corporation Yard serves as a command post. It is the location from which site access and operations are controlled. It should be continuously occupied as long as team members are on site.
- Shower thoroughly as soon as possible after removing protective equipment.
- Wash hands thoroughly upon leaving any area of suspected contamination.
- All personal safety equipment is to be tested by the ERSO prior to work site entrance, and the condition of the equipment must be acceptable to the ERSO.
- All personnel who will enter a work site should wear secure identification (e.g., badge with photo and name on a chain around the neck; name on clothing). A name on the hard hat is <u>not</u> secure identification. Identification must be visible even when all protective equipment or gear is worn.
- Never assume that a situation is as safe as it appears to be.
- Be alert to any unusual behavior on the part of other workers which might indicate distress, disorientation, or other ill effects. Be alert to any unusual changes in your own condition; never ignore warning signs or hesitate to report them at once. Inform

each other of symptoms of nausea, dizziness, headache, or respiratory or eye irritation.

- Maintain a clean and organized work area.
- Delineate work zones with barricades and markers.
- Label raw materials, debris, scrap, waste, intermediates, and contaminated clothing with appropriate and understandable precautionary labels.
- Post notices in areas with high noise levels, and require personal protective equipment.
- Inspect fire extinguishers monthly for adequate pressure.
- Inspect emergency eyewash/showers for proper operation daily before work begins.
- Allow only trained and experienced operators to operate heavy equipment on site.
- Non-DOE contractors shall remain outside the intraline distance to all explosives storage and operating facilities.
- Do not handle any explosives or explosives device.
- Smoke only in designated smoking areas.
- Obtain a Hazardous Work Permit for use of open flame, spark, or heat producing (>109°C) equipment or tools.

9.3. Field Briefings

Field briefings shall occur at a minimum, weekly, and more frequent if work activities and hazards necessitate it. The ERSO shall conduct field health and safety briefings that include:

- Work activities.
- Health and safety requirements.
- Work zones.
- Evacuation routes.
- Assembly point upwind of work area, in case of emergency.
- Emergency signals.
- Location of first aid and emergency safety equipment.
- Daily briefings are recommended.

9.4. First Aid

The ERSO shall identify and maintain a list of those individuals who have previously completed American Red Cross training programs in First Aid and CPR. These individuals should be appointed as alternates for the ERSO if he is incapacitated or needs assistance. Specific responsibilities for these individuals shall be delineated by the ERSO. The ERSO should consider the familiarity of these individuals with the following topics:

- Principles of first aid.
- Restoration of breathing/CPR.
- Control of bleeding.
- Recognition and treatment of physical shock.
- Open and closed wounds and burns.
- Fractures and dislocations.
- Recognition of and treatment for heat stress.
- Snake bites.

10. Operations

Operations shall be conducted in a safe manner consistent with the policies and procedures outlined in this Plan. The number of personnel shall be restricted to the minimum necessary to complete the required work as an administrative control to limit personnel exposures to site chemical hazards. All operations shall follow the pertinent safety procedures.

10.1. Work Site Practices

The prohibited practices and general safety requirements listed in Section 9 are applicable to this site work. In addition, no worker may engage in any activity for which the health and safety consequences of his/her actions are unclear (e.g., previously unplanned work) without the approval of the ERSO. If such activities become necessary to complete any phase of the work, a project instruction or procedure shall be developed and followed.

Smoking shall not be permitted in any restricted work location or other locations posted "No Smoking" by LLNL. Smoking is permitted only in designated locations.

10.2. Work Zones

Site access shall be controlled to reduce the possibility of entry by unauthorized or unprotected individuals and to prevent the transfer of contaminants by personnel or equipment from the site. Three zones may be required to accomplish these goals. The exclusion zone, the contamination reduction zone, and the support zone, if established, will be delineated by barricades and flagging as appropriate. Zones will be established by the ERSO with consultation with Hazards Control, based on local conditions. The ERSO or designee will be alert to persons entering active zones and will prohibit unauthorized or unprotected persons from entering these zones. These zones may be modified or expanded by the ERSO or Hazards Control depending upon changing wind and site conditions.

Exclusion Zone

The exclusion zone shall include, at a minimum, the immediate vicinity of the work area plus an additional 15-foot corridor. Persons entering this zone are required to wear personal protective equipment as prescribed by the ERSO and Hazards Control, and as outlined in the site-specific health plan for that area.

Contamination Reduction Zone

The contamination reduction zone shall be located upwind at the entrance to the exclusion zone. The purpose of this zone is to prevent the transfer of contaminants by personnel or equipment exiting the exclusion zone. All decontamination activities shall occur in this area.

Support Zone

The support zone is the outermost zone and is considered to be a non-contaminated or clean area. Any supplies, equipment, or personnel required to support site activities should be kept in this zone.

10.3. Physical Control Measures

All areas and containers where potentially contaminated soil or water are to be stored unattended and any excavations, which are to be left open and unattended, are to be surrounded by a barricade to prevent accidental access by unauthorized personnel.

10.4. Hazard Control Measures

Specific considerations shall be given to the following topics to ensure that adequate hazard control measures are implemented for site operations:

- Minimization of dust generation.
- Prevention of surface contamination by subsurface material or vice versa.
- Decontamination of sampling equipment.
- Decontamination of excavation/construction/maintenance equipment.
- Decontamination and disposal of personnel protective apparel and equipment.
- Use of decontamination solutions—acids, alkalis, solvents.
- Use of acids in the field for sample preservation.
- Disposition of decontamination solutions or any other materials used on equipment, surfaces, or systems.
- Disposal of drilling spoils and other wastes associated with environmental characterization.
- Disposition of contaminated materials such as placement in 55-gallon drums which may be sealed and disposed of as necessary.
- Monitoring for flammable/explosive vapors.
- Minimization of personnel exposures through appropriate use of administrative work practices consistent with ALARA.
- Handling and disposal of contaminated water, filtrates, etc.
- Use and operation of electrical equipment.
- Use and maintenance of personnel protective apparel and equipment.
- Heavy equipment operations and safety protocols (See Appendix E).

- Direct reading instrumentation protocols and techniques for estimating real-time chemical exposures on site.
- Respiratory protection as per 29 CFR 1910.134 and ANSI Z88.2.

10.5. Fire Protection

Employees shall be informed of the fire hazards of the materials and processes to which they are exposed. Upon initial assignment, each employee shall be trained in the portions of the fire prevention plan that will protect the employee in the event of an emergency.

The hazardous waste sites at LLNL have the fire hazards typical of construction sites and chemical treatment facilities such as: combustible and flammable materials; potential for explosive atmospheres; occasional welding and open flames; oxidizers; and motor fuels.

To ensure that fire and explosion hazards are minimized, plans and procedures must be coordinated with the LLNL Fire Department (911). If suitable water supplies are unavailable or where water use may be inappropriate, 20- or 30-lb ABC fire extinguishers may be necessary for each drill rig or field crew. No smoking is allowed in the work area nor near any flammable materials, and open flames require prior authorization.

ERSO is responsible for ensuring the maintenance of any fire prevention and suppression systems or equipment used on the hazardous waste sites.

The accumulation of flammable and combustible waste materials shall be minimized as a means of fire prevention.

10.6. Communications

The ERSO shall maintain contact with workers on a continuing basis. Individuals shall meet at the checkpoint established by the ERSO prior to work site entry and register. Each worker shall ensure that he maintains contact with other workers or his "buddy." No individual may either enter or leave the work site alone. Exiting workers shall inform the ERSO that they are departing.

10.7. Personnel Protection Plan

Environmental operations can pose unusual health and safety problems. A very careful review of OSHA and EPA regulations, and other applicable standards, and guidelines by the ERSO is important. At a minimum, these requirements may include:

- Medical surveillance.
- Personnel exposure monitoring program.
- Respiratory protection.
- Personal protective equipment and clothing.
- Prohibited activities.
- Compliance program.

- Hygiene facilities and practices.
- Employee information and training.
- Recordkeeping.

Many of these topics have been addressed in other sections.

Occupationally Related Chemical/Radiological Hazards: Exposure of Individuals in Controlled Areas

Exposures shall be limited to levels prescribed in

OSHA: 29 CFR 1910

ACGIH: "Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment and Biological Exposure Indices"

DOE: DOE Order 5480.11, "Requirements for Radiation Protection," and all other applicable standards, DOE orders, and recommended limits.

Chemical Hazards: Exposure of Individuals and Population Groups in Uncontrolled Areas

Exposures to members of the public shall be as low as reasonable achievable (ALARA) within standards prescribed by EPA for particular substances.

10.8. Safety

The industrial safety aspects of this program shall focus on evaluation of hazards associated with:

- Transportation equipment.
- Material handling equipment (e.g., cranes, hoists, and fork trucks).
- Machine guards/safe guards.
- Hand and portable power tools.
- Lasers.
- Pressure/cryogenic equipment.
- Electrical equipment (i.e., motors, relays, and starters).
- Fall protection equipment.
- Slings and below-the-hook lifting devices.
- Seismic/storage.
- Eye protection.
- Portable ladders.
- Construction.

Prior to the initiation of work and weekly thereafter, safety inspections shall be conducted by the ERSO or his designee. These inspections include those activities necessary to ensure the safe operating condition of all equipment consistent with 29 CFR 1910 and 1926. Additionally, it will be the responsibility of LLNL's subcontractors to provide a routine maintenance program for this equipment.

The areas accessible by employees will be provided with adequate illumination while work is in progress in accordance with **Table H120.1.**

Table H120.1. Minimum illumination intensities in foot-candles.

Foot-candles	Area or operations
5	General site areas.
3	Excavation and waste area, accessways, active storage areas, loading platforms, refueling, and field maintenance areas.
5	Indoors: Warehouse, corridors, hallways, and exitways.
5	Tunnels, shafts, and general underground work areas.(Exception: Minimum of 10 foot-candles is required at tunnel and shaft heading during drilling, mucking, and scaling. Mine Safety and Health Administration approved caps lights shall be acceptable for use in the tunnel heading.
10	General shops (e.g., mechanical and electrical equipment rooms, active storerooms, barracks or living quarters, locker or dressing room, dining areas, and indoor toilets and workrooms).
30	First aid stations, infirmaries, and offices.

Although drums and containers and hazardous waste are not routinely handled during site operations, the provisions of 29 CFR 1910.120 (j), "Handling Drums and Containers" shall be implemented as appropriate.

10.9. Record Keeping

Health and safety records shall be maintained in accordance with applicable regulatory requirements. Records are maintained for LLNL personnel at the LLNL Health Services offices documenting medical surveillance, respiratory protection training and testing, injuries, illnesses, area and personal air sampling results, and physical agent measurements. All subcontractors working on the project are required to maintain similar records at their respective offices and make them available for inspection by LLNL Health Services, if requested.

Material Safety Data Sheets (MSDSs) can be obtained by contacting the manufacturer or by contacting the MSDS hotline at 3-2122 to request copies of MSDSs for specific chemicals.

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Appendix A

Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ALARA	As low as reasonably achievable
ALI	Annual limit on intake
CFR	Code of Federal Regulations
DAC	Derived air concentration
DOE	Department of Energy
EPA	Environmental Protection Agency
f_1	Alternative gastrointestinal-tract absorption factor
ERSO	Environmental Restoration Safety Officer
HE	High explosives
HEPA	High efficiency particulate filter
IDLH	Immediately dangerous to life or health concentration which represents the maximum level from which one could escape within 30 minutes without any escape-impairing symptoms or any other irreversible health effects.
LEL/UEL -	Lower and upper explosive limits. Percent by volume of potentially explosive substance in air.
LFL/UFL -	Lower and upper flammable limits. Percent by volume of potentially flammable substance in air.
MSDS	Material Safety Data Sheets
NIOSH	National Institute for Occupational Safety and Health.
OSHA	Occupational Safety and Health Administration.
OVA	Organic Vapor Analyzer
PEL	Permissible exposure limit set by OSHA. Values usually are expressed in ppm or mg/m^3. PELs are expressed as: (1) 8-hr TWA exposure limit (2) Ceiling exposure limit: at no time shall an employee's exposure exceed this limit (3) Short-term exposure limit (STEL) (4) Maximum peak: acceptable above the specified ceiling limit for the stated concentration and duration.
PID	Photoionization detector (PID)
PPE	Personal protective equipment
RCRA	Resource Conservation and Recovery Act
TLV	Threshold limit value as issued by ACGIH. Values usually are expressed in ppm or mg/m^3. TLVs are expressed as:

	(1) TLV-TWA: the TWA concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. (2) TLV-STEL: the 15-min TWA to which a worker can be exposed for a period of up to 15 minutes continuously without suffering from irritation, chronic or irreversible tissue damage, or narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce worker efficiency, and provided that the daily TLV-TWA is not exceeded.
TWA	Time-weighted average. This is generally expressed as an 8-hour TWA.

Appendix B

Material Safety Data Sheets

PRODUCT #: 12545 NAME: BENZENE
MATERIAL SAFETY DATA SHEET, Valid 8/94 - 10/94
Printed Tuesday, August 16, 1994 10:47AM

Sigma Chemical Co.
P.O. Box 14508
St. Louis, MO 63178
Phone: 314-771-5765

Aldrich Chemical Co.
1001 West St. Paul
Milwaukee, WI 53233
Phone: 414-273-3850

Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779
Phone: 516-467-0980
Emergency Phone: 516-467-3535

SECTION 1. - - - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - - - -

PRODUCT #: 12545 NAME: BENZENE

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -

CAS #:71-43-2
MF: C_6H_6

SYNONYMS

(6)ANNULENE * BENZEEN (DUTCH) * BENZEN (POLISH) * BENZENE (ACGIH,DOT, OSHA) * BENZIN (OBS.) * BENZINE (OBS.) * BENZOL * BENZOLE * BENZOLENE * BENZOLO (ITALIAN) * BICARBURET OF HYDROGEN * CARBON OIL * COAL NAPHTHA * CYCLOHEXATRIENE * FENZEN (CZECH) * MINERAL NAPHTHA * MOTOR BENZOL * NCI-C55276 * NITRATION BENZENE * PHENE * PHENYL HYDRIDE * PYROBENZOL * PYROBENZOLE * RCRA WASTE NUMBER U019 * UN1114 (DOT) *

SECTION 3. - - - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - - -

LABEL PRECAUTIONARY STATEMENTS

FLAMMABLE (USA DEFINITION)
HIGHLY FLAMMABLE (EUROPEAN DEFINITION)
TOXIC
MAY CAUSE CANCER.
MAY CAUSE HERITABLE GENETIC DAMAGE.
TOXIC BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
TARGET ORGAN(S):
BLOOD
BONE MARROW
EYES
KEEP AWAY FROM SOURCES OF IGNITION. NO SMOKING.
IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).
TAKE OFF IMMEDIATELY ALL CONTAMINATED CLOTHING.
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION.

SECTION 4. - - - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
ASSURE ADEQUATE FLUSHING OF THE EYES BY SEPARATING THE EYELIDS WITH FINGERS.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
REMOVE AND WASH CONTAMINATED CLOTHING PROMPTLY.

SECTION 5. - - - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - - -

EXTINGUISHING MEDIA

CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.
WATER MAY BE EFFECTIVE FOR COOLING, BUT MAY NOT EFFECT EXTINGUISHMENT.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
USE WATER SPRAY TO COOL FIRE-EXPOSED CONTAINERS.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

DANGER:
EXTREMELY FLAMMABLE.
VAPOR MAY TRAVEL CONSIDERABLE DISTANCE TO SOURCE OF IGNITION AND FLASH BACK.
CONTAINER EXPLOSION MAY OCCUR UNDER FIRE CONDITIONS.

SECTION 6. - - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - - -

EVACUATE AREA.
SHUT OFF ALL SOURCES OF IGNITION.
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
COVER WITH AN ACTIVATED CARBON ADSORBENT, TAKE UP AND PLACE IN CLOSED CONTAINERS. TRANSPORT OUTDOORS.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - - -

REFER TO SECTION 8.

SECTION 8. - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
USE NONSPARKING TOOLS.
DO NOT BREATHE VAPOR.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
CARCINOGEN.
TOXIC.
SEVERE EYE IRRITANT.
MUTAGEN.
KEEP TIGHTLY CLOSED.
KEEP AWAY FROM HEAT, SPARKS, AND OPEN FLAME.
STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - -

APPEARANCE AND ODOR

COLORLESS LIQUID
BOILING POINT: 80 C TO 80.2 C
MELTING POINT: 5.5 C
FLASHPOINT 12 F
- 11C
AUTOIGNITION TEMPERATURE: 1043 F 561C
UPPER EXPLOSION LEVEL: 8%
LOWER EXPLOSION LEVEL: 1.3%
VAPOR PRESSURE: 74.6MM 20 C 166MM 37.7 C
VAPOR DENSITY: 2.77
SPECIFIC GRAVITY: 0.874

SECTION 10. - - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - -

INCOMPATIBILITIES

OXIDIZING AGENTS

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS

TOXIC FUMES OF:

CARBON MONOXIDE, CARBON DIOXIDE

SECTION 11. - - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - -

ACUTE EFFECTS

DANGER: CONTAINS BENZENE, CANCER HAZARD.
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
MATERIAL IS IRRITATING TO MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.
CAUSES SKIN IRRITATION.
CAUSES SEVERE EYE IRRITATION.
EXPOSURE CAN CAUSE:
NAUSEA, DIZZINESS AND HEADACHE
NARCOTIC EFFECT

CHRONIC EFFECTS

CARCINOGEN.
MAY ALTER GENETIC MATERIAL.
BLOOD EFFECTS
TARGET ORGAN(S):
BLOOD
BONE MARROW
EYES

ADDITIONAL INFORMATION

INHALATION OF HIGH CONCENTRATIONS OF BENZENE MAY HAVE AN INITIAL STIMULATORY EFFECT ON THE CENTRAL NERVOUS SYSTEM CHARACTERIZED BY EXHILARATION, NERVOUS EXCITATION AND/OR GIDDINESS, DEPRESSION, DROWSINESS, OR FATIGUE. THE VICTIM MAY EXPERIENCE TIGHTNESS IN THE CHEST, BREATHLESSNESS AND LOSS OF CONSCIOUSNESS. TREMORS, CONVULSIONS AND DEATH DUE TO RESPIRATORY PARALYSIS OR CIRCULATORY COLLAPSE CAN OCCUR IN A FEW MINUTES TO SEVERAL HOURS FOLLOWING SEVERE EXPOSURES. ASPIRATION OF SMALL AMOUNTS OF LIQUID IMMEDIATELY CAUSES PULMONARY EDEMA AND HEMORRHAGE OF PULMONARY TISSUE. DIRECT SKIN CONTACT MAY CAUSE ERYTHEMA. REPEATED OR PROLONGED SKIN CONTACT MAY RESULT IN DRYING, SCALING DERMATITIS OR DEVELOPMENT OF SECONDARY SKIN INFECTIONS. THE CHIEF TARGET ORGAN IS THE HEMATOPOIETIC SYSTEM. BLEEDING FROM THE NOSE, GUMS OR MUCOUS MEMBRANES AND THE DEVELOPMENT OF PURPURIC SPOTS, PANCYTOPENIA, LEUKOPENIA, THROMBOCYTOPENIA, APLASTIC ANEMIA AND LEUKEMIA MAY OCCUR AS THE CONDITION PROGRESSES. THE BONE MARROW MAY APPEAR NORMAL, APLASTIC OR HYPERPLASTIC, AND MAY NOT CORRELATE WITH PERIPHERAL BLOOD-FORMING TISSUES. THE ONSET OF EFFECTS OF PROLONGED BENZENE EXPOSURE MAY BE DELAYED FOR MANY MONTHS OR YEARS AFTER THE ACTUAL EXPOSURE HAS CEASED.

RTECS NO: CY1400000
BENZENE

IRRITATION DATA

SKN-RBT 15 MG/24H OPEN MLD	AIHAAP 23,95,62
SKN-RBT 20 MG/24H MOD	85JCAE -,25,86
EYE-RBT 88 MG MOD	AMIHAB 14,387,56
EYE-RBT 2 MG/24H SEV	85JCAE -,25,86

TOXICITY DATA

IHL-HMN LCLO:2 PPH/5M	TABIA2 3,231,33
ORL-MAN LDLO:50 MG/KG	YAKUD5 22,883,80
IHL-HMN LCLO:2000 PPM/5M	YAKUD5 22,883,80
IHL-HMN LCLO:65 MG/M3/5Y	ARGEAR 44,145,74
UNR-MAN LDLO:194 MG/KG	85DCAI 2,73,70
ORL-RAT LD50:930 MG/KG	TXAPA9 7,767,65

IHL-RAT LC50:10000 PPM/7H	28ZRAQ -,113,60
IPR-RAT LD50:2890 UG/KG	36YFAG -,302,77
ORL-MUS LD50:4700 MG/KG	HYSAAV 32(3),349,67
IHL-MUS LC50:9980 PPM	JIHTAB 25,366,43
IPR-MUS LD50:340 MG/KG	ANYAA9 243,104,75
SKN-RBT LD50:>9400 MG/KG	TXAPA9 7,559,65
SKN-GPG LD50:>9400 MG/KG	TXAPA9 7,559,65
ORL-MAM LD50:5700 MG/KG	GISAAA 39(4),86,74

TARGET ORGAN DATA

PERIPHERAL NERVE AND SENSATION (SPASTIC PARALYSIS WITH/WITHOUT SENSORY CH
PERIPHERAL NERVE AND SENSATION (FLACCID PARALYSIS WITHOUT ANESTHESIA)
SENSE ORGANS AND SPECIAL SENSES (HEMORRHAGE)
SENSE ORGANS AND SPECIAL SENSES (TUMORS)
BEHAVIORAL (SOMNOLENCE)
BEHAVIORAL (TREMOR)
BEHAVIORAL (CONVULSIONS OR EFFECT ON SEIZURE THRESHOLD)
BEHAVIORAL (IRRITABILITY)
LUNGS, THORAX OR RESPIRATION (CHRONIC PULMONARY EDEMA OR CONGESTION)
LUNGS, THORAX OR RESPIRATION (TUMORS)
GASTROINTESTINAL (GASTRITIS)
GASTROINTESTINAL (NAUSEA OR VOMITING)
LIVER (OTHER CHANGES)
BLOOD (CHANGES IN CELL COUNT)
BLOOD (OTHER CHANGES)
BLOOD (LEUKEMIA)
BLOOD (LYMPHOMA INCLUDING HODGKIN'S DISEASE)
SKIN AND APPENDAGES (AFTER SYSTEMIC EXPOSURE: DERMATITIS, OTHER)
EFFECTS ON FERTILITY (PRE-IMPLANTATION MORTALITY)
EFFECTS ON FERTILITY (POST-IMPLANTATION MORTALITY)
EFFECTS ON FERTILITY (ABORTION)
EFFECTS ON EMBRYO OR FETUS (EXTRA EMBRYONIC STRUCTURES)
EFFECTS ON EMBRYO OR FETUS (CYTOLOGICAL CHANGES)
EFFECTS ON EMBRYO OR FETUS (FETOTOXICITY)
EFFECTS ON EMBRYO OR FETUS (FETAL DEATH)
EFFECTS ON EMBRYO OR FETUS (OTHER EFFECTS TO EMBYRO OR FETUS)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (MUSCULOSKELETAL SYSTEM)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (BLOOD AND LYMPHATIC SYSTEMS)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (HEPATOBILIARY SYSTEM)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (OTHER DEVELOPMENTAL ABNORMALITIES)
EFFECTS ON NEWBORN (BIOCHEMICAL AND METABOLIC)
NUTRITIONAL AND GROSS METABOLIC (BODY TEMPERATURE INCREASE)
TUMORIGENIC (CARCINOGENIC BY RTECS CRITERIA)
TUMORIGENIC (NEOPLASTIC BY RTECS CRITERIA)
TUMORIGENIC (EQUIVOCAL TUMORIGENIC AGENT BY RTECS CRITERIA)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - - -

BURN IN A CHEMICAL INCINERATOR EQUIPPED WITH AN AFTERBURNER AND SCRUBBER BUT EXERT EXTRA CARE IN IGNITING AS THIS MATERIAL IS HIGHLY FLAMMABLE.

OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - - -
CONTACT FLUKA CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - - -
TLV AND SOURCE
FOR BENZENE:
ACGIH TLV-TWA: 10 PPM.
OSHA PEL: 8H TWA 1 PPM; STEL: 5 PPM (15 MIN.).

REVIEWS, STANDARDS, AND REGULATIONS

ACGIH TLV-SUSPECTED HUMAN CARCINOGEN	85INA8 6,108,91
ACGIH TLV-TWA 10 PPM	85INA8 6,108,91
IARC CANCER REVIEW:HUMAN LIMITED EVIDENCE	IMEMDT 7,203,74
IARC CANCER REVIEW:ANIMAL SUFFICIENT EVIDENCE	IMSUDL 7,120,87
IARC CANCER REVIEW:ANIMAL LIMITED EVIDENCE	IMEMDT 29,93,82
IARC CANCER REVIEW:HUMAN SUFFICIENT EVIDENCE	IMEMDT 29,93,82
IARC CANCER REVIEW:ANIMAL INADEQUATE EVIDENCE	IMEMDT 7,203,74
IARC CANCER REVIEW:GROUP 1	IMSUDL 7,120,87

MSHA STANDARD:AIR-CL 25 PPM (80 MG/M3) (SKIN)
DTLVS* 3,22,71
OSHA-CANCER HAZARD
FEREAC 52,34460,87
OEL-AUSTRALIA:TWA 5 PPM (16 MG/M3);CARCINOGEN JAN93
OEL-BELGIUM:TWA 10 PPM (32 MG/M3);CARCINOGEN JAN93
OEL-CZECHOSLOVAKIA:TWA 10 MG/M3;STEL 20 MG/M3 JAN93
OEL-DENMARK:TWA 5 PPM (16 MG/M3);SKIN;CARCINOGEN JAN93
OEL-FINLAND:TWA 5 PPM (15 MG/M3);STEL 10 PPM (30 MG/M3);SKIN;CAR JAN93
OEL-FRANCE:TWA 5 PPM (16 MG/M3);CARCINOGEN JAN93
OEL-GERMANY;SKIN;CARCINOGEN JAN93
OEL-HUNGARY:STEL 5 MG/M3;SKIN;CARCINOGEN JAN93
OEL-INDIA:TWA 10 PPM (30 MG/M3);CARCINOGEN JAN93
OEL-JAPAN:TWA 10 PPM (32 MG/M3);STEL 25 PPM (80 MG/M3);CAR JAN93
OEL-THE NETHERLANDS:TWA 10 PPM (30 MG/M3);SKIN JAN93
OEL-THE PHILIPPINES:TWA 25 PPM (80 MG/M3);SKIN JAN93
OEL-POLAND:TWA 30 MG/M3;SKIN JAN93
OEL-RUSSIA:TWA 10 PPM (5 MG/M3);STEL 25 PPM (15 MG/M3);SKIN;CAR JAN93
OEL-SWEDEN:TWA 1 PPM (3 MG/M3);STEL 5 PPM (16 MG/M3);SKIN;CAR JAN93
OEL-SWITZERLAND:TWA 5 PPM (16 MG/M3);SKIN;CARCINOGEN JAN93
OEL-THAILAND:TWA 10 PPM (30 MG/M3);STEL 25 PPM (75 MG/M3) JAN93
OEL-TURKEY:TWA 20 PPM (64 MG/M3);SKIN JAN93
OEL-UNITED KINGDOM:TWA 10 PPM (30 MG/M3) JAN93
OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA CHECK ACGIH TLV
OEL IN NEW ZEALAND, SINGAPORE, VIETNAM CHECK ACGIH TLV
NIOSH REL TO BENZENE-AIR:8H CA TWA 0.1 PPM;CL 1 PPM/15M
NIOSH* DHHS #92-100,92
NOHS 1974: HZD 09070; NIS 126; TNF 11184; NOS 106; TNE 147583
NOES 1983: HZD 09070; NIS 59; TNF 5311; NOS 88; TNE 81737; TFE 18573
ATSDR TOXICOLOGY PROFILE (NTIS** PB/89/209464/AS)
EPA GENETOX PROGRAM 1988, POSITIVE: CARCINOGENICITY-MOUSE/RAT
EPA GENETOX PROGRAM 1988, POSITIVE: IN VITRO CYTOGENETICS-HUMAN LYMPHOCYTE
EPA GENETOX PROGRAM 1988, POSITIVE: IN VIVO CYTOGENETICS-HUMAN LYMPHOCYTE
EPA GENETOX PROGRAM 1988, POSITIVE: MAMMALIAN MICRONUCLEUS; SPERM MORPHOLOGY-MOUSE
EPA GENETOX PROGRAM 1988, NEGATIVE: CELL TRANSFORM.-SA7/SHE; IN VITRO

SCE-HUMAN LYMPHOCYTES
EPA GENETOX PROGRAM 1988, NEGATIVE: IN VITRO SCE-HUMAN
EPA TSCA CHEMICAL INVENTORY, JUNE 1993
EPA TSCA SECTION 8(E) STATUS REPORT
8EHQ-0680-0345;8EHQ-1277-0027;8EHQ-0378-0112
EPA TSCA SECTION 8(E) STATUS REPORT 8EHQ-0978-0244;8EHQ-0379-0277
EPA TSCA SECTION 8(E) STATUS REPORT 8EHQ-0378-0112
ON EPA IRIS DATABASE
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 1994
NIOSH ANALYTICAL METHODS: SEE HYDROCARBONS, AROMATIC, 1501;
HYDROCARBONS, BP 36-126 C, 1500;
NIOSH ANALYTICAL METHODS: SEE BENZENE BY PORTABLE GC, 3700
NIOSH ANALYTICAL METHODS: SEE HYDROCARBONS, AROMATIC 1501
NTP CARCINOGENESIS STUDIES (GAVAGE);CLEAR EVIDENCE:MOUSE,RAT
NTPTR* NTP-TR-289,86
NTP 7TH ANNUAL REPORT ON CARCINOGENS, 1992 : KNOWN TO BE CARCINOGENIC
OSHA ANALYTICAL METHOD #12
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

SECTION 16. - - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - -

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. SIGMA, ALDRICH, FLUKA SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

PRODUCT #: 20279-7 NAME: BERYLLIUM, FLAKE, 99.99%
MATERIAL SAFETY DATA SHEET, Valid 8/94 - 10/94
Printed Tuesday, August 16, 1994 11:11AM

Sigma Chemical Co.
P.O. Box 14508
St. Louis, MO 63178
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1001 West St. Paul
Milwaukee, WI 53233
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Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779
Phone: 516-467-0980
Emergency Phone: 516-467-3535

SECTION 1. - - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - - -

PRODUCT #: 20279-7 NAME: BERYLLIUM, FLAKE, 99.99%

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -

CAS #:7440-41-7
MF: BE

SYNONYMS

BERYLLIUM-9 * BERYLLIUM (ACGIH,OSHA) * BERYLLIUM COMPOUNDS, N.O.S. (UN1566) (DOT) * BERYLLIUM, POWDER (UN1567) (DOT) * GLUCINIUM * GLUCINUM * RCRA WASTE NUMBER P015 * UN1566 (DOT) * UN1567 (DOT) *

SECTION 3. - - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - -

LABEL PRECAUTIONARY STATEMENTS

HIGHLY TOXIC (USA DEFINITION)
TOXIC (EUROPEAN DEFINITION)
MAY CAUSE CANCER.
MAY CAUSE HERITABLE GENETIC DAMAGE.
TOXIC BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
MUTAGEN.
CAUSES SEVERE IRRITATION.
TARGET ORGAN(S):
LUNGS
HANDLE WITH GLOVES IN HOOD.
IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
AFTER CONTACT WITH SKIN, WASH IMMEDIATELY WITH PLENTY OF WATER.
DO NOT BREATHE DUST.
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION.

SECTION 4. - - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -

FLUSH SKIN WITH WATER.
IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.
CALL A PHYSICIAN IMMEDIATELY.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

SECTION 5. - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - -

EXTINGUISHING MEDIA

DRY CHEMICAL POWDER.
DO NOT USE CARBON DIOXIDE EXTINGUISHER ON THIS MATERIAL.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

SECTION 6. - - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - - -

EVACUATE AREA.
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - - -

REFER TO SECTION 8.

SECTION 8. - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -

CHEMICAL SAFETY GOGGLES.
SAFETY SHOWER AND EYE BATH.
RUBBER APRON.
NIOSH/MSHA-APPROVED RESPIRATOR.
USE ONLY IN A CHEMICAL FUME HOOD.
WEAR HEAVY RUBBER GLOVES.
DO NOT BREATHE DUST.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
DO NOT USE IF SKIN IS CUT OR SCRATCHED. WASH THOROUGHLY AFTER HANDLING.
CARCINOGEN.
HIGHLY TOXIC.
SEVERE IRRITANT.
MUTAGEN.
KEEP TIGHTLY CLOSED.
STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - - -

APPEARANCE AND ODOR
SILVER-GREY FLAKES
SPECIFIC GRAVITY: 1.850

SECTION 10. - - - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - - -

INCOMPATIBILITIES
ACIDS
BASES
HALOGENS
HALIDES
ALKALI METALS
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
NATURE OF DECOMPOSITION PRODUCTS NOT KNOWN.

SECTION 11. - - - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - - -

ACUTE EFFECTS
MAY BE FATAL IF INHALED, SWALLOWED, OR ABSORBED THROUGH SKIN.
INHALATION MAY BE FATAL AS A RESULT OF SPASM, INFLAMMATION AND EDEMA OF THE LARYNX AND BRONCHI, CHEMICAL PNEUMONITIS AND PULMONARY EDEMA.
CAUSES SEVERE IRRITATION.
CHRONIC EFFECTS
CARCINOGEN.
MAY ALTER GENETIC MATERIAL.
TARGET ORGAN(S):
LUNGS
RTECS NO: DS1750000
BERYLLIUM
TOXICITY DATA

IVN-RAT LD50:496 UG/KG	LAINAW 15,176,66

TARGET ORGAN DATA

LUNGS, THORAX OR RESPIRATION (TUMORS)
LUNGS, THORAX OR RESPIRATION (BRONCHOGENIC CARCINOMA)
LIVER (HEPATITIS: HEPATOCELLULAR NECROSIS, ZONAL)
MUSCULO-SKELETAL (TUMORS)
TUMORIGENIC (NEOPLASTIC BY RTECS CRITERIA)
TUMORIGENIC (EQUIVOCAL TUMORIGENIC AGENT BY RTECS CRITERIA)
ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - - -

MATERIAL IN THE ELEMENTAL STATE SHOULD BE RECOVERED FOR REUSE OR RECYCLING.

OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - - -

CONTACT ALDRICH CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - -

REVIEWS, STANDARDS, AND REGULATIONS

ACGIH TLV-SUSPECTED HUMAN CARCINOGEN	85INA8	6,134,91
ACGIH TLV-TWA 0.002 MG/M3	85INA8	6,134,91
IARC CANCER REVIEW:ANIMAL SUFFICIENT EVIDENCE	IMEMDT	1,17,72
IARC CANCER REVIEW:ANIMAL SUFFICIENT EVIDENCE	IMEMDT	23,143,80
IARC CANCER REVIEW:ANIMAL SUFFICIENT EVIDENCE	IMEMDT	58,41,93
IARC CANCER REVIEW:HUMAN LIMITED EVIDENCE	IMEMDT	23,143,80
IARC CANCER REVIEW:HUMAN SUFFICIENT EVIDENCE	IMEMDT	58,41,93
IARC CANCER REVIEW:GROUP 1	IMEMDT	58,41,93

MSHA STANDARD-AIR:TWA 0.002 MG/M3
DTLVS* 3,24,71
OSHA PEL:8H TWA 0.002 MG(BE)/M3;CL 0.005 MG/M3;PK 0.025 MG/M3/30M
FEREAC 54,2923,89
OSHA PEL FINAL:8H TWA 0.002 MG(BE)/M3;STEL 0.005/30M;CL 0.025 MG/M3
FEREAC 54,2923,89
OEL-ARAB REPUBLIC OF EGYPT:TWA 0.002 MG/M3 JAN93
OEL-AUSTRALIA:TWA 0.002 MG/M3;CARCINOGEN JAN93
OEL-BELGIUM:TWA 0.002 MG/M3;CARCINOGEN JAN93
OEL-CZECHOSLOVAKIA:TWA 0.001 MG/M3;STEL 0.002 MG/M3 JAN93
OEL-DENMARK:TWA 0.001 MG/M3;CARCINOGEN JAN93
OEL-FINLAND:TWA 0.002 MG/M3;STEL 0.006 MG/M3;CARCINOGEN JAN93
OEL-FRANCE:TWA 0.002 MG/M3;CARCINOGEN JAN93
OEL-GERMANY;CARCINOGEN JAN93
OEL-HUNGARY:STEL 0.001 MG/M3;CARCINOGEN JAN93
OEL-INDIA:TWA 0.002 MG/M3;CARCINOGEN JAN93
OEL-JAPAN:TWA 0.002 MG/M3;CARCINOGEN JAN93
OEL-THE NETHERLANDS:TWA 0.002 MG/M3 JAN93
OEL-THE PHILIPPINES:TWA 0.002 MG/M3 JAN93
OEL-POLAND:TWA 0.001 MG/M3 JAN93
OEL-RUSSIA:STEL 0.001 MG/M3;CARCINOGEN JAN93
OEL-SWEDEN:TWA 0.002 MG/M3;CARCINOGEN JAN93
OEL-SWITZERLAND:TWA 0.002 MG/M3;CARCINOGEN JAN93
OEL-THAILAND:TWA 0.002 MG/M3;STEL 0.005 MG/M3 JAN93
OEL-TURKEY:TWA 0.002 MG/M3 JAN93
OEL-UNITED KINGDOM:TWA 0.002 MG/M3 JAN93

OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA CHECK ACGIH TLV
OEL IN NEW ZEALAND, SINGAPORE, VIETNAM CHECK ACGIH TLV
NIOSH REL TO BERYLLIUM-AIR:CA NOT TO EXCEED 0.0005 MG(BE)/M3
NIOSH* DHHS #92-100,92
NOHS 1974: HZD 11770; NIS 8; TNF 344; NOS 17; TNE 10510
NOES 1983: HZD 11770; NIS 22; TNF 421; NOS 29; TNE 13938; TFE 739
ATSDR TOXICOLOGY PROFILE (NTIS** PB/89/148233/AS)
EPA GENETOX PROGRAM 1988, POSITIVE: CARCINOGENICITY-MOUSE/RAT
EPA TSCA CHEMICAL INVENTORY, JUNE 1993
EPA TSCA SECTION 8(E) STATUS REPORT 8EHQ-0680-0345
ON EPA IRIS DATABASE
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 1994
NIOSH ANALYTICAL METHODS: SEE BERYLLIUM, 7102; ELEMENTS, 7300
NIOSH ANALYTICAL METHODS: SEE ELEMENTS (ICP) 7300
NTP 7TH ANNUAL REPORT ON CARCINOGENS, 1992 : ANTICIPATED TO BE CARCINOGEN

SECTION 16. - - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - -

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. SIGMA, ALDRICH, FLUKA SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

OHS05990

SECTION 1 CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

OCCUPATIONAL HEALTH SERVICES, INC.
11 WEST 42ND STREET, 12TH FLOOR
NEW YORK, NEW YORK 10036
1-800-445-MSDS (1-800-445-6737) OR
1-212-789-3535

FOR EMERGENCY SOURCE INFORMATION
CONTACT: 1-615-366-2000 USA

CAS NUMBER: 121-82-4
RTECS NUMBER: XY9450000

SUBSTANCE: CYCLOTRIMETHYLENETRINITRAMINE

TRADE NAMES/SYNONYMS:
1,3,5-TRIAZINE, HEXAHYDRO-1,3,5-TRINITRO-;
HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE;
S-TRIAZINE, HEXAHYDRO-1,3,5-TRINITRO-; HEXAHYDRO-1,3,5-TRINITRO-S-TRIAZINE;
CYCLONITE; CYCLOTRIMETHYLENENITRAMINE; SYM-TRIMETHYLENETRINITRAMINE;
TRIMETHYLENETRINITRAMINE; HEXOGEN; RDX; T4; C3H6N6O6; OHS05990

CHEMICAL FAMILY:
Amine, alicyclic

Nitro

CREATION DATE: 06/27/86 REVISION DATE: 03/04/94

SECTION 2 COMPOSITION/INFORMATION ON INGREDIENTS

COMPONENT : CYCLOTRIMETHYLENETRINITRAMINE
CAS NUMBER: 121-82-4
PERCENTAGE: 100.0

OTHER CONTAMINANTS: NONE

SECTION 3 HAZARDS IDENTIFICATION

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=3 REACTIVITY=3 PERSISTENCE=2
NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=3 REACTIVITY=4

EMERGENCY OVERVIEW:
White, odorless crystalline powder.

Harmful if swallowed. May be irritating to the respiratory tract, skin and eyes. May cause convulsions. May affect the central nervous system. May cause adverse reproductive effects. May explode from heat, shock or friction.

Do not grind or subject to heat or shock. Keep away from heat, sparks and flame. Avoid breathing dust. Avoid contact with eyes, skin and clothing. Avoid contamination by any source. Keep container tightly closed. Wash thoroughly after handling. Use only with adequate ventilation.

POTENTIAL HEALTH EFFECTS:

INHALATION:
SHORT TERM EFFECTS: May cause irritation.
LONG TERM EFFECTS: May cause nausea, vomiting, headache, weakness, dizziness, restlessness, sleeplessness, loss of memory, convulsions and unconsciousness.

SKIN CONTACT:
SHORT TERM EFFECTS: May cause irritation.
LONG TERM EFFECTS: May cause effects as reported in long term inhalation. Same effects as short term exposure.

EYE CONTACT:
SHORT TERM EFFECTS: May cause irritation.
LONG TERM EFFECTS: No information is available.

INGESTION:
SHORT TERM EFFECTS: No information available on significant adverse effects.
LONG TERM EFFECTS: May cause effects as reported in long term inhalation. Additional effects may include twitching and convulsions. May also cause reproductive effects.

CARCINOGEN STATUS:
OSHA: N
NTP: N
IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION:
FIRST AID- Remove from exposure area to fresh air immediately. If breathing has stopped, perform artificial respiration. Keep person warm and at rest. Treat symptomatically and supportively. Get medical attention immediately.

SKIN CONTACT:
FIRST AID- Remove contaminated clothing and shoes immediately. Wash affected area with soap or mild detergent and large amounts of water until no evidence of chemical remains (approximately 15-20 minutes). Get medical attention immediately.

EYE CONTACT:
FIRST AID- Wash eyes immediately with large amounts of water or normal saline, occasionally lifting upper and lower lids, until no evidence of chemical remains (approximately 15-20 minutes). Get medical attention immediately.

INGESTION:
FIRST AID- If extensive vomiting has not occurred, the substance should be removed by emesis or gastric lavage provided that the patient is conscious and convulsions are not present. Keep head below hips during vomiting to prevent aspiration. Do not attempt to make an unconscious person vomit. Treat symptomatically and supportively. Get medical attention immediately (Dreisbach, Handbook of Poisoning, 12th Ed.). Treatment should be performed by qualified medical personnel.

NOTE TO PHYSICIAN

ANTIDOTE:
No specific antidote. Treat symptomatically and supportively.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD:
Dangerous fire hazard when exposed to heat or flame.

Dangerous explosion hazard when exposed to heat or flame.

EXTINGUISHING MEDIA:
Flood with water, if no water available use carbon dioxide, dry chemical or earth
(1990 Emergency Response Guidebook, DOT P 5800.5).

FIREFIGHTING:
Do not move containers if exposure to heat has occurred. Do not fight fire when it reaches storage or cargo area. Withdraw from area and let fire burn. If possibility exists that Class A explosives are involved, evacuate to a distance of 3/4 mile for tractor/trailer load; 1 mile for a railcar load. (1990 Emergency Response Guidebook, DOT P 5800.5, Guide Page 46).

Dangerously explosive. Do not fight fire in cargo area, evacuate area and let burn. Avoid breathing dusts and fumes. Evacuate to a radius of 5000 feet if material on fire or involved in a fire.

HAZARDOUS COMBUSTION PRODUCTS:
Thermal decomposition products may include toxic oxides of nitrogen.

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL:
Shut off ignition sources. Do not touch spilled material. No smoking, flames or flares in hazard area. Evacuate area for 2500 feet in all directions. Keep unnecessary people away.

SECTION 7 HANDLING AND STORAGE

Observe all federal, state and local regulations when storing this substance.

Store away from incompatible substances.

Store in accordance with 27 CFR Subpart K and 29 CFR 1910.109.

Consult NFPA publication 495, Explosives, Storage and Use, for proper storage and handling requirements.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS:
CYCLOTRIMETHYLENETRINITRAMINE:
  1.5 mg/m3 OSHA TWA (skin)
  1.5 mg/m3 ACGIH TWA (skin)
  1.5 mg/m3 NIOSH recommended TWA (skin);
  3 mg/m3 NIOSH recommended STEL

OSHA revoked the final rule limits of January 19, 1989 in response to the 11th Circuit Court of Appeals decision (AFL-CIO v. OSHA) effective June 30, 1993. See 29 CFR 1910.1000 (58 FR 35338)

VENTILATION:
Provide local exhaust or process enclosure ventilation to meet the published exposure limits. Ventilation equipment should be explosion-proof if explosive concentrations of dust, vapor or fume are present.

EYE PROTECTION:
Employee must wear splash-proof or dust-resistant safety goggles to prevent eye contact with this substance.

Emergency eye wash: Where there is any possibility that an employee's eyes may be exposed to this substance, the employer should provide an eye wash fountain within the immediate work area for emergency use.

CLOTHING:
Employee must wear appropriate protective (impervious) clothing and equipment to prevent repeated or prolonged skin contact with this substance.

GLOVES:
Employee must wear appropriate protective gloves to prevent contact with this substance.

RESPIRATOR:
The following respirators are recommended based on information found in the physical data, toxicity and health effects sections. They are ranked in order from minimum to maximum respiratory protection.
The specific respirator selected must be based on contamination levels found in the work place, must be based on the specific operation, must not exceed the working limits of the respirator and must be jointly approved by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration (NIOSH-MSHA).

Any dust and mist respirator.

Any air-purifying respirator with a high-efficiency particulate filter.

Any powered air-purifying respirator with a dust and mist filter.

Any powered air-purifying respirator with a high-efficiency particulate filter.

Any type 'C' supplied-air respirator operated in the pressure-demand or other positive pressure or continuous-flow mode.

Any self-contained breathing apparatus.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION: White, odorless crystalline powder.
MOLECULAR WEIGHT: 222.12
MOLECULAR FORMULA: (C-H2-N2-O2)3
BOILING POINT: not available
MELTING POINT: 401-403 F (205-206 C)
VAPOR PRESSURE: negligible
SPECIFIC GRAVITY: 1.82
WATER SOLUBILITY: insoluble
SOLVENT SOLUBILITY: Soluble in acetone; slightly soluble in ether, ethyl acetate, glacial acetic acid, methanol; insoluble in alcohol, carbon disulfide, and carbon tetrachloride.

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY:
CYCLOTRIMETHYLENETRINITRAMINE:
Exposure to heat, friction, shock, or electrostatic discharge may initiate detonation.

CONDITIONS TO AVOID:
Do not allow fire to reach cargo area.

INCOMPATIBILITIES:
CYCLOTRIMETHYLENETRINITRAMINE:
  ACIDS: Incompatible.
  ALKALIS: Incompatible.
  GLASS: Incompatible.
  SAND: Incompatible.
  MERCURY FULMINATE: May easily initiate an explosion.
  METAL FRAGMENTS: Incompatible.

HAZARDOUS DECOMPOSITION:
Thermal decomposition products may include toxic oxides of nitrogen.

POLYMERIZATION:
Hazardous polymerization has not been reported to occur under normal

temperatures and pressures.

SECTION 11 TOXICOLOGY INFORMATION

CYCLOTRIMETHYLENETRINITRAMINE:
TOXICITY DATA: 85 mg/kg oral-child TDLo; 100 mg/kg oral-rat LD50; 59 mg/kg oral-mouse LD50; 500 mg/kg oral-rabbit LDLo; 100 mg/kg oral-cat LDLo; 3600 mg/kg/90 days continuous oral-rat TDLo; 2275 mg/kg/13 weeks continuous oral-rat TDLo; 28800 mg/kg/90 days continuous oral-mouse TDLo; 1800 mg/kg/6 weeks intermittent oral-dog TDLo; 18 mg/kg intravenous-rat LDLo; 19 mg/kg intravenous-mouse LD50; 25 mg/kg intravenous-guinea pig LD50; 10 mg/kg intraperitoneal-rat LDLo; reproductive effects data (RTECS).
CARCINOGEN STATUS: None.
ACUTE TOXICITY LEVEL: Toxic by ingestion.
TARGET EFFECTS: Poisoning may affect the central nervous system.

HEALTH EFFECTS
INHALATION:
CYCLOTRIMETHYLENETRINITRAMINE:
ACUTE EXPOSURE- May cause irritation of the respiratory tract.
CHRONIC EXPOSURE- Workers exposed have experienced epileptiform convulsions or became unconscious without convulsions. The premonitory symptoms included headache, dizziness, nausea, and vomiting. When consciousness was regained (within a few minutes to 24 hours) intermittent stupor, weakness, and nausea continued. Seizures were followed by temporary post convulsive amnesia, malaise, fatigue, and asthenia. A few days of irritability, insomnia, or restlessness may also precede convulsions.

SKIN CONTACT:
CYCLOTRIMETHYLENETRINITRAMINE:
ACUTE EXPOSURE- May cause irritation.
CHRONIC EXPOSURE- Repeated or prolonged exposure may cause effects as in chronic inhalation. Primary and sensitizing dermatitis has been reported, however likely caused by impurities or chemical intermediates associated with its production.

EYE CONTACT:
CYCLOTRIMETHYLENETRINITRAMINE:
ACUTE EXPOSURE- May cause irritation.
CHRONIC EXPOSURE- No data available.

INGESTION:
CYCLOTRIMETHYLENETRINITRAMINE:
TOXIC.
ACUTE EXPOSURE- The lethal dose reported in rats was 100 mg/kg. The symptoms were not reported.
CHRONIC EXPOSURE- Repeated ingestion may cause effects as in chronic inhalation. Rats fed diets containing up to 600 mg/kg/day for 13 weeks experienced hypotriglyceridemia, hyperreactivity, tremors, convulsions and death. An apparent dose related incidence of leukocytosis occurred in females. Multifocal degenerative testicular lesions were seen in males fed 300 or 600 mg/kg/day. Reproductive effects have been reported in

animals.

SECTION 12 ECOLOGICAL INFORMATION

ENVIRONMENTAL IMPACT RATING (0-4): no data available

ACUTE AQUATIC TOXICITY: no data available

DEGRADABILITY: no data available

LOG BIOCONCENTRATION FACTOR (BCF): no data available

LOG OCTANOL/WATER PARTITION COEFFICIENT: no data available

SECTION 13 DISPOSAL INFORMATION

Observe all federal, state and local regulations when disposing of this substance.

Disposal must be in accordance with standards applicable to generators of hazardous waste, 40 CFR 262. EPA Hazardous Waste Number D003.
100 pound CERCLA Section 103 Reportable Quantity.

SECTION 14 TRANSPORTATION INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION HAZARD CLASS OR DIVISION, 49 CFR 172.101:
None - forbidden explosives

SECTION 15 REGULATORY INFORMATION

TSCA STATUS: Y

CERCLA SECTION 103 (40CFR302.4):	N
SARA SECTION 302 (40CFR355.30):	N
SARA SECTION 304 (40CFR355.40):	N
SARA SECTION 313 (40CFR372.65):	N
OSHA PROCESS SAFETY (29CFR1910.119):	N
CALIFORNIA PROPOSITION 65:	N

SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40 CFR 370.21)

ACUTE HAZARD:	Y
CHRONIC HAZARD:	N
FIRE HAZARD:	Y
REACTIVITY HAZARD:	Y
SUDDEN RELEASE HAZARD:	Y

SECTION 16 OTHER

OHS06100

SECTION 1 CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

OCCUPATIONAL HEALTH SERVICES, INC.
11 WEST 42ND STREET, 12TH FLOOR
NEW YORK, NEW YORK 10036
1-800-445-MSDS (1-800-445-6737) OR
1-212-789-3535

FOR EMERGENCY SOURCE INFORMATION
CONTACT: 1-615-366-2000 USA

CAS NUMBER: 2691-41-0
RTECS NUMBER: XF7450000

SUBSTANCE: CYCLOTETRAMETHYLENETETRANITRAMINE

TRADE NAMES/SYNONYMS:
OCTAHYDRO-1,3,5,7,-TETRANITRO-1,3,5,7,-TETRAZOCINE; HMX; BETA-HMX; HOMOCYCLONITE; OCTOGEN; 1,3,5,7-TETRAZOCINE, OCTAHYDRO-1,3,5,7-TETRANITRO-; TETRAMETHYLENETETRANITRAMINE; CYCLOTETRAMETHYLENE TETRANITRAMINE; 1,3,5,7-TETRANITROPERHYDRO-1,3,5,7-TETRAZOCINE; CYCLOTETRAMETHYLENE TETRANITRAMINE, WET WITH NOT LESS THAN 15% WATER; C4H8N8O8; UN 0226; STCC 4901548; OHS06100

CHEMICAL FAMILY:
Amine, alicyclic

Nitro

CREATION DATE: 06/30/86 REVISION DATE: 01/15/94

SECTION 2 COMPOSITION/INFORMATION ON INGREDIENTS

COMPONENT : CYCLOTETRAMETHYLENETETRANITRAMINE
CAS NUMBER: 2691-41-0
PERCENTAGE: <90

COMPONENT : WATER
PERCENTAGE: >15

OTHER CONTAMINANTS: NONE.

SECTION 3 HAZARDS IDENTIFICATION

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=3 REACTIVITY=3 PERSISTENCE=2
NFPA RATINGS (SCALE 0-4): HEALTH=3 FIRE=4 REACTIVITY=4

EMERGENCY OVERVIEW:
Colorless to white crystals wetted with water.
Harmful if absorbed through skin. May be irritating to eyes. May affect the central nervous system. May explode from heat, shock or friction. May form flammable or explosive dust-air mixtures.

Do not grind or subject to heat or shock. Keep away from heat, sparks and flame. Avoid breathing dust. Avoid contact with eyes, skin and clothing. Avoid contamination by any source. Keep container tightly closed. Avoid creation of dust. Wash thoroughly after handling. Use only with adequate ventilation.

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EFFECTS: No information is available.
LONG TERM EFFECTS: No information is available.
SKIN CONTACT:
SHORT TERM EFFECTS: May cause death.
LONG TERM EFFECTS: May cause redness and swelling of the skin and shock.
EYE CONTACT:
SHORT TERM EFFECTS: May cause irritation.
LONG TERM EFFECTS: No information is available.
INGESTION:
SHORT TERM EFFECTS: May cause drunkeness.
LONG TERM EFFECTS: No information is available.

CARCINOGEN STATUS:
OSHA: N
NTP: N
IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION:
FIRST AID- Remove from exposure area to fresh air immediately. If breathing has stopped, perform artificial respiration. Keep person warm and at rest. Treat symptomatically and supportively. Get medical attention immediately.

SKIN CONTACT:
FIRST AID- Remove contaminated clothing and shoes immediately. Wash affected area with soap or mild detergent and large amounts of water until no evidence of chemical remains (approximately 15-20 minutes). Get medical attention immediately.

EYE CONTACT:
FIRST AID- Wash eyes immediately with large amounts of water or normal saline, occasionally lifting upper and lower lids, until no evidence of chemical remains (approximately 15-20 minutes). Get medical attention immediately.

INGESTION:
FIRST AID- Treat symptomatically and supportively. Get medical attention immediately. If vomiting occurs, keep head lower than hips to prevent aspiration.

NOTE TO PHYSICIAN
ANTIDOTE:
No specific antidote. Treat symptomatically and supportively.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD:

Dangerous fire hazard when exposed to heat or flame.

Dangerous explosion hazard when exposed to heat or flame.

Dust-air mixtures may ignite or explode.

EXTINGUISHING MEDIA:

Flood with water, if no water available use carbon dioxide, dry chemical or earth
(1990 Emergency Response Guidebook, DOT P 5800.5).

FIREFIGHTING:

Do not move containers if exposure to heat has occurred. Do not fight fire when it reaches storage or cargo area. Withdraw from area and let fire burn. If possibility exists that Class A explosives are involved, evacuate to a distance of 3/4 mile for tractor/trailer load; 1 mile for a railcar load. (1990 Emergency Response Guidebook, DOT P 5800.5, Guide Page 46).

Dangerously explosive. Do not fight fire in cargo area. Evacuate area and let burn.

HAZARDOUS COMBUSTION PRODUCTS:

Thermal decomposition products may include toxic oxides of nitrogen.

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL:

Shut off ignition sources. Do not touch spilled material. No smoking, flames or flares in hazard area. Evacuate area for 2500 feet in all directions. Keep unnecessary people away.

SECTION 7 HANDLING AND STORAGE

Observe all federal, state and local regulations when storing this substance.

Store in accordance with 27 CFR Subpart K and 29 CFR 1910.109.

Consult NFPA publication 495, Explosives, Storage and Use, for proper storage and handling requirements.

Store away from incompatible substances.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS:

No occupational exposure limits established by OSHA, ACGIH, or NIOSH.

VENTILATION:
Provide local exhaust or process enclosure ventilation. Ventilation equipment should be explosion-proof if explosive concentrations of dust, vapor or fume are present.

EYE PROTECTION:
Employee must wear splash-proof or dust-resistant safety goggles to prevent eye contact with this substance.

Emergency eye wash: Where there is any possibility that an employee's eyes may be exposed to this substance, the employer should provide an eye wash fountain within the immediate work area for emergency use.

CLOTHING:
Employee must wear appropriate protective (impervious) clothing and equipment to prevent repeated or prolonged skin contact with this substance.

GLOVES:
Employee must wear appropriate protective gloves to prevent contact with this substance.

RESPIRATOR:
The following respirators are recommended based on information found in the physical data, toxicity and health effects sections. They are ranked in order from minimum to maximum respiratory protection.
The specific respirator selected must be based on contamination levels found in the work place, must be based on the specific operation, must not exceed the working limits of the respirator and must be jointly approved by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration (NIOSH-MSHA).

Any type 'C' supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet or hood operated in continuous-flow mode.

Any self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION: Colorless to white crystals wetted with water.
MOLECULAR WEIGHT: 296.20

MOLECULAR FORMULA: C4-H8-N8-O8
MELTING POINT: 527 F (275 C)
SPECIFIC GRAVITY: not available
WATER SOLUBILITY: insoluble
SOLVENT SOLUBILITY: Soluble in acetone; sparingly soluble in ether and ethanol.

DEFLAGRATION POINT (VIOLENT DECOMPOSITION): 534-549 F (279-287 C)

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY:
CYCLOTETRAMETHYLENETETRANITRAMINE:
Exposure to heat, friction or shock may initiate detonation.

CONDITIONS TO AVOID:
Do not allow fire to reach cargo area.

INCOMPATIBILITIES:
CYCLOTETRAMETHYLENETETRANITRAMINE:
MERCURY FULMINATE: May easily initiate an explosion.
METAL AZIDES: May initiate detonation.
OXIDIZERS (STRONG): Fire and explosion hazard.

HAZARDOUS DECOMPOSITION:
Thermal decomposition products may include toxic oxides of nitrogen.

POLYMERIZATION:
Hazardous polymerization has not been reported to occur under normal temperatures and pressures.

SECTION 11 TOXICOLOGY INFORMATION

CYCLOTETRAMETHYLENETETRANITRAMINE:
IRRITATION DATA: 500 mg skin-rabbit mild.
TOXICITY DATA: 630 mg/kg skin-rabbit LD50; 6490 mg/kg oral-rat LD50; 300 mg/kg oral-guinea pig LD50; 1500 mg/kg oral-mouse LD50; 50 mg/kg oral-rabbit LD50; 40 mg/kg intravenous-dog LDLo; 28 mg/kg intravenous-guinea pig LD50; 25 mg/kg intravenous-rat LD50; 10 mg/kg intravenous-rabbit LD50; 2700 mg/kg unreported route-mouse LD50; 7300 mg/kg unreported route-rat LD50.
CARCINOGEN STATUS: None.
ACUTE TOXICITY LEVEL: Toxic by dermal absorption; slightly toxic by ingestion.
TARGET EFFECTS: No data available.

HEALTH EFFECTS
INHALATION:
CYCLOTETRAMETHYLENETETRANITRAMINE:
ACUTE EXPOSURE- No data available.
CHRONIC EXPOSURE- No data available.

SKIN CONTACT:

CYCLOTETRAMETHYLENETETRANITRAMINE:
TOXIC.
ACUTE EXPOSURE- The lethal dose reported in rabbits was 630 mg/kg. The symptoms were not reported.
CHRONIC EXPOSURE- Dermatitis and circulatory collapse with central nervous system disturbances have been reported in animals.

EYE CONTACT:
CYCLOTETRAMETHYLENETETRANITRAMINE:
ACUTE EXPOSURE- May cause irritation.
CHRONIC EXPOSURE- No data available.

INGESTION:
CYCLOTETRAMETHYLENETETRANITRAMINE:
ACUTE EXPOSURE- May cause narcosis.
CHRONIC EXPOSURE- No data available.

SECTION 12 ECOLOGICAL INFORMATION

ENVIRONMENTAL IMPACT RATING (0-4): no data available

ACUTE AQUATIC TOXICITY: no data available

DEGRADABILITY: no data available

LOG BIOCONCENTRATION FACTOR (BCF): no data available

LOG OCTANOL/WATER PARTITION COEFFICIENT: no data available

SECTION 13 DISPOSAL INFORMATION

Observe all federal, state and local regulations when disposing of this substance.

Disposal must be in accordance with standards applicable to generators of hazardous waste, 40 CFR 262. EPA hazardous waste numbers, D001 and D003.
100 pound CERCLA Section 103 Reportable Quantity.

SECTION 14 TRANSPORTATION INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION SHIPPING NAME-ID NUMBER, 49 CFR 172.101:
Octogen, wetted-UN 0226

U.S. DEPARTMENT OF TRANSPORTATION HAZARD CLASS OR DIVISION, 49 CFR 172.101:
1.1 - Explosives (with a mass explosion hazard)

U.S. DEPARTMENT OF TRANSPORTATION PACKING GROUP, 49 CFR 172.101:
PG II

U.S. DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS, 49 CFR 172.101 AND SUBPART E:

Explosive 1.1d

U.S. DEPARTMENT OF TRANSPORTATION PACKAGING AUTHORIZATIONS:
EXCEPTIONS: None
NON-BULK PACKAGING: 49 CFR 173.62
BULK PACKAGING: None

U.S. DEPARTMENT OF TRANSPORTATION QUANTITY LIMITATIONS 49 CFR 172.101:
PASSENGER AIRCRAFT OR RAILCAR: Forbidden
CARGO AIRCRAFT ONLY: Forbidden

SECTION 15 REGULATORY INFORMATION

TSCA STATUS: Y

CERCLA SECTION 103 (40CFR302.4): N
SARA SECTION 302 (40CFR355.30): N
SARA SECTION 304 (40CFR355.40): N
SARA SECTION 313 (40CFR372.65): N
OSHA PROCESS SAFETY (29CFR1910.119): N
CALIFORNIA PROPOSITION 65: N

SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40 CFR 370.21)
ACUTE HAZARD: Y
CHRONIC HAZARD: N
FIRE HAZARD: Y
REACTIVITY HAZARD: Y
SUDDEN RELEASE HAZARD: Y

SECTION 16 OTHER

MSDS

Canadian Centre for Occupational Health and Safety

*** IDENTIFICATION ***

RECORD NUMBER : 704071
LANGUAGE : ENGLISH
PRODUCT NAME(S) : DIESEL FUEL 1
PRODUCT IDENTIFICATION DATA : PRODUCT CODE R00000005102
DATE OF MSDS : 1993-01-05

*** MANUFACTURER INFORMATION ***

MANUFACTURER : SUN COMPANY, INC
ADDRESS : Ten Penn Center
1801 Market Street
Philadelphia Pennsylvania
U.S.A. 19103-1699
Telephone: 215-977-6182 (Joanne Houck)
EMERGENCY TELEPHONE NO.(S) : 800-964-8861 (SUN COMPANY, AFTER NORMAL BUSINESS HOURS)
800-424-9300 (CHEMTREC, AFTER NORMAL BUSINESS HOURS)

*** MATERIAL SAFETY DATA ***

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1. CHEMICAL PRODUCT AND COMPANY INFORMATION

REVISION DATE: 01/05/1993
UN NUMBER- NA1993

PRIMARY APPLICATION- FUEL OIL

MANUFACTURER- SUN COMPANY, INC.
TEN PENN CENTER
1801 MARKET STREET
PHILADELPHIA PA 19103-1699

SYNONYMS.......: FUEL OIL
CAS REGISTRY NO: 64742-81-0
CAS NAME.......: HYDRODESULFURIZED KEROSENE
CHEMICAL FAMILY: PETROLEUM HYDROCARBON
INFORMATION
SUPPLIER... JOANNE HOUCK
PHONE.....: (215) 977-6133

EMERGENCY PHONE NUMBERS (AFTER NORMAL BUSINESS HOURS)
SUN CO.. 1-800-964-8861
CHEMTREC. 1-800-424-9300

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2. COMPOSITION / INFORMATION ON INGREDIENTS

EXPOSURE GUIDELINES
OSHA ACGIH SUN/MFR

COMPONENT/CAS NO.	LO%	HI%	TWA	STEL	TWA	STEL	TWA	STEL	UNIT
LIMITS FOR THE PRODUCT:							100		PPM
HYDRODESULFURIZED KEROSENE 64742-81-0	99.99	99.99					100		PPM
PROPRIETARY ADDITIVES	.01	.01			NO SPECIFIC LIMIT				

ADDITIONAL EXPOSURE LIMITS ---------------- SUN RECOMMENDATION

8 HR. TIME WEIGHTED PERMISSIBLE EXPOSURE- _____100 PPM 500 MG/M3

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3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW --------------------

DANGER] COMBUSTIBLE. HARMFUL IF INHALED. HIGH VAPOR CONCENTRATIONS MAY CAUSE DIZZINESS. MAY CAUSE SKIN IRRITATION. HARMFUL OR FATAL IF SWALLOWED. PULMONARY ASPIRATION HAZARD-CAN ENTER LUNGS AND CAUSE DAMAGE. CONTAINS MATERIAL WHICH MAY CAUSE CANCER. BASED ON ANIMAL DATA.

APPEARANCE-- CLEAR LIQUID. ODOR-- KEROSENE-LIKE ODOR

POTENTIAL HEALTH EFFECTS --------------

PRIMARY ROUTES OF ENTRY- INHALATION(X) SKIN(X) EYE(X) INGESTION(X)

INHALATION ------------------------------------

EXCESSIVE EXPOSURES MAY CAUSE IRRITATION TO EYES, NOSE, THROAT AND LUNGS. RESPIRATORY TRACT; CENTRAL NERVOUS SYSTEM (BRAIN) EFFECTS; HEADACHES, NAUSEA; UNCONSCIOUSNESS, COMA; RESPIRATORY FAILURE AND DEATH.

SKIN --

PRACTICALLY NON-TOXIC IF ABSORBED (LD50 GREATER THAN 2000 MG/KG). CONTAINS A MATERIAL WHICH HAS CAUSED SKIN TUMORS IN LAB ANIMALS. MAY CAUSE MODERATE IRRITATION WITH PROLONGED OR REPEATED CONTACT.

EYE ---

CONTACT WITH THE EYE MAY CAUSE MINIMAL IRRITATION.

INGESTION -------------------------------------

HARMFUL OR FATAL IF SWALLOWED. PULMONARY ASPIRATION HAZARD IF SWALLOWED AND/OR VOMITING OCCURS - CAN ENTER LUNGS AND CAUSE DAMAGE.

CARCINOGEN LISTED BY-IARC(NO) NTP(NO) OSHA(NO) ACGIH(NO) OTHER(NO)

PRE-EXISTING MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE-

DISORDERS OR DISEASES OF THE SKIN, EYE, NERVOUS SYSTEM, RESPIRATORY AND/OR PULMONARY SYSTEM, LUNG (E.G. ASTHMA-LIKE CONDITIONS).

---

4. FIRST AID MEASURES

INHALATION ------------------------------------

MOVE PERSON TO FRESH AIR. IF NOT BREATHING, GIVE ARTIFICIAL RESPIRATION, OBTAIN MEDICAL ASSISTANCE.

SKIN --

WASH WITH SOAP AND WATER UNTIL NO ODOR REMAINS. IF REDNESS OR SWELLING

DEVELOPS, OBTAIN MEDICAL ASSISTANCE. IMMEDIATELY REMOVE SOAKED CLOTHING. WASH CLOTHING BEFORE REUSE.

EYE --

FLUSH WITH WATER FOR AT LEAST 15 MINUTES. IF IRRITATION PERSISTS, OBTAIN MEDICAL ASSISTANCE.

INGESTION --

DO NOT INDUCE VOMITING] DO NOT GIVE LIQUIDS] OBTAIN EMERGENCY MEDICAL ATTENTION. SMALL AMOUNTS WHICH ACCIDENTALLY ENTER MOUTH SHOULD BE RINSED OUT UNTIL TASTE OF IT IS GONE.

==

5. FIRE FIGHTING MEASURES

FLASH POINT: 125 MINIMUM PMCC (DEG. F); 52 MINIMUM PMCC (DEG. C)
AUTOIGNITION TEMP.: 444 ESTIMATED (DEG. F); 229 ESTIMATED (DEG. C)

---FLAMMABLE LIMITS IN AIR---
LOWER EXPLOSIVE LIMIT (LEL): 0.7 % VOLUME
UPPER EXPLOSIVE LIMIT (UEL): 5.0 % VOLUME

FIRE AND EXPLOSION HAZARDS -----------------

COMBUSTIBLE (FLASH POINT 100 TO 200F)

EXTINGUISHING-MEDIA -----------------------

WATER SPRAY. REGULAR FOAM. DRY CHEMICAL. CARBON DIOXIDE.

SPECIAL FIRE FIGHTING INSTRUCTIONS ---------

COOL TANK/ CONTAINER. WEAR SELF-CONTAINED BREATHING APPARATUS. WEAR STRUCTURAL FIREFIGHTERS PROTECTIVE CLOTHING.

NFPA/HMIS CLASSIFICATION
HEALTH - 0 / 0
FIRE - 2 / 2
REACTIVITY - 0 / 0
PERSONAL PROTECTION INDEX - X

HAZARD RATING
0=LEAST 1=SLIGHT
2=MODERATE 3=HIGH
4=EXTREME

SPECIFIC HAZARD: COMBUSTIBLE

==

6. ACCIDENTAL RELEASE MEASURES

PREVENT IGNITION; STOP LEAK; VENTILATE AREA. CONTAIN SPILL. FOR LARGE SPILL, LEAK OR RELEASE. USE PERSONAL PROTECTIVE EQUIPMENT STATED IN SECTION 8. ADVISE EPA; STATE AGENCY IF REQUIRED. ABSORB ON INERT MATERIAL. SHOVEL, SWEEP OR VACUUM SPILL.

==

7. HANDLING AND STORAGE

KEEP AWAY FROM HEAT, SPARKS AND FLAME. KEEP CONTAINER TIGHTLY CLOSED. KEEP IN WELL VENTILATED SPACE. NFPA CLASS IIIA STORAGE. TRANSFER OPERATIONS MUST BE ELECTRICALLY GROUNDED TO DISSIPATE STATIC BUILDUP. AVOID PROLONGED BREATHING OF MIST OR VAPOR. AVOID PROLONGED OR REPEATED CONTACT WITH SKIN. AVOID CONTACT WITH EYES. PROTECT CYLINDERS FROM DAMAGE.

8. EXPOSURE CONTROL / PERSONAL PROTECTION

CONSULT WITH A HEALTH/SAFETY PROFESSIONAL FOR SPECIFIC SELECTION.

VENTILATION ----------------------------------

USE ONLY WITH ADEQUATE VENTILATION. MECHANICAL VENTILATION RECOMMENDED. GENERAL DILUTION VENTILATION ACCEPTABLE.

PERSONAL PROTECTIVE EQUIPMENT ----------------

EYE --

SPLASH PROOF CHEMICAL GOGGLES OR FULL FACE SHIELD RECOMMENDED TO PROTECT AGAINST SPLASH OF PRODUCT.

GLOVES ---------------------------------------

PROTECTIVE GLOVES RECOMMENDED TO PROTECT AGAINST CONTACT WITH PRODUCT. THE FOLLOWING GLOVE MATERIALS ARE ACCEPTABLE: POLYVINYL CHLORIDE (PVC); NEOPRENE; NITRILE; POLYVINYL ALCOHOL; VITON;

RESPIRATOR ----------------------------------

CONCENTRATION-IN-AIR DETERMINES PROTECTION NEEDED. USE ONLY NIOSH CERTIFIED RESPIRATORY PROTECTION. HALF-MASK AIR PURIFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGES IS ACCEPTABLE TO 10 TIMES THE EXPOSURE LIMIT. FULL-FACE AIR PURIFYING RESPIRATOR WITH ORGANIC VAPOR CARTRIDGES IS ACCEPTABLE TO 50 TIMES THE EXPOSURE LIMIT NOT TO EXCEED THE CARTRIDGE LIMIT OF 1000 PPM. PROTECTION BY AIR PURIFYING RESPIRATORS IS LIMITED. USE A POSITIVE PRESSURE-DEMAND FULL-FACE SUPPLIED AIR RESPIRATOR OR SCBA FOR EXPOSURES ABOVE 50X THE EXPOSURE LIMIT. IF EXPOSURE IS ABOVE IDLH(IMMEDIATELY DANGEROUS TO LIFE & HEALTH) OR THERE IS THE POSSIBILITY OF AN UNCONTROLLED RELEASE OR EXPOSURE LEVELS ARE UNKNOWN THEN USE A POSITIVE PRESSURE-DEMAND FULL-FACE SUPPLIED AIR RESPIRATOR WITH ESCAPE BOTTLE OR SCBA.

OTHER --

AVOID ALL SKIN CONTACT. IF CONTACT IS UNAVOIDABLE, WEAR CHEMICAL RESISTANT CLOTHING. THE FOLLOWING MATERIALS ARE ACCEPTABLE AS PROTECTIVE CLOTHING MATERIALS: POLYVINYL ALCOHOL(PVA); POLYVINYL CHLORIDE(PVC); NEOPRENE; NITRILE; VITON; POLYURETHANE; SAFETY SHOWER AND EYE WASH AVAILABILITY RECOMMENDED. LAUNDER SOILED CLOTHES. FOR NON-FIRE EMERGENCIES, POSITIVE PRESSURE SELF-CONTAINED BREATHING APPARATUS (SCBA) & STRUCTURAL FIREFIGHTERS' PROTECTIVE CLOTHING WILL PROVIDE LIMITED PROTECTION.

9. PHYSICAL AND CHEMICAL PROPERTIES

BOILING POINT.......: 340 TO 570 (DEG. F) _____ 171 TO 299 (DEG. C)
MELTING POINT.......: N/A (DEG. F) _____ N/A (DEG. C)
SPECIFIC GRAVITY....: 0.81 (WATER=1)
PACKING DENSITY.....: N/A (KG/M3)
VAPOR PRESSURE......: 2 EST'D (MM HG @ 20 DEG C)
VAPOR DENSITY.......: 6 (AIR=1)
SOLUBILITY IN WATER.: NIL (% BY VOLUME)
PH INFORMATION......: N/A AT CONC. N.D. G/L H2O
% VOLATILES BY VOL..: 100
EVAPORATION RATE....: 600 X SLOWER (ETHYL ETHER=1)
OCTANOL/WATER COEFF.: N.D.
APPEARANCE..........: CLEAR LIQUID.
ODOR................: KEROSENE-LIKE ODOR

ODOR THRESHOLD......: N.D. (PPM)
VISCOSITY...........: N.D. SUS @ N.D DEG F ... 2.1 CST @ 40 DEG C
MOLECULAR WEIGHT....: N.D. (G/MOLE)

10. STABILITY AND REACTIVITY

STABILITY ----------------------------------
STABLE.
CONDITIONS TO AVOID-
HEAT, SPARKS AND OPEN FLAMES.
INCOMPATIBLE MATERIALS ---------------------
STRONG OXIDIZERS.
HAZARDOUS DECOMPOSITION --------------------
COMBUSTION WILL PRODUCE CARBON MONOXIDE, ASPHYXIANTS.
POLYMERIZATION ----------------------------
WILL NOT OCCUR.

11. TOXICOLOGICAL INFORMATION

FOR THE PRODUCT ------------

INHALATION: OVEREXPOSURE MAY CAUSE IRRITATION TO EYES, NOSE, THROAT, & RESPIRATORY TRACT, CENTRAL NERVOUS SYSTEM (BRAIN) EFFECTS, DIZZINESS, LOSS OF BALANCE & COORDINATION, RESPIRATORY FAILURE & DEATH. SKIN: LOW ACUTE TOXICITY. MODERATE IRRITATION WITH PROLONGED AND REPEATED CONTACT. EYE: MINIMAL IRRITATION. ORAL: HARMFUL OR FATAL IF SWALLOWED: PULMONARY ASPIRATION HAZARD-- CAN ENTER LUNGS AND CAUSE DAMAGE. AMERICAN PETROLEUM INSTITUTE STUDIES HAVE SHOWN THAT KEROSENE PRODUCED SKIN CANCER IN MICE WHEN REPEATEDLY APPLIED WITHOUT WASHING BETWEEN APPLICATIONS FOR 2 YEARS. SEE COMPONENT FOR ADDITIONAL HEALTH HAZARD INFORMATION.

HYDRODESULFURIZED KEROSENE (COMPONENT)

INHALATION: OVEREXPOSURE MAY CAUSE IRRITATION TO EYES, NOSE, THROAT, & RESPIRATORY TRACT, CENTRAL NERVOUS SYSTEM (BRAIN) EFFECTS, DIZZINESS, LOSS OF BALANCE & COORDINATION, RESPIRATORY FAILURE & DEATH. SKIN: LOW ACUTE TOXICITY. MODERATE IRRITATION WITH PROLONGED AND REPEATED CONTACT. EYE: MINIMAL IRRITATION. ORAL: HARMFUL OR FATAL IF SWALLOWED: PULMONARY ASPIRATION HAZARD-- CAN ENTER LUNGS AND CAUSE DAMAGE. AMERICAN PETROLEUM INSTITUTE STUDIES HAVE SHOWN THAT KEROSENE PRODUCED SKIN CANCER IN MICE WHEN REPEATEDLY APPLIED WITHOUT WASHING BETWEEN APPLICATIONS FOR 2 YEARS.

PROPRIETARY ADDITIVES (COMPONENT)

COMPONENT(S) IDENTITY NOT SPECIFIED: NO TOXICOLOGY STATEMENT AVAILABLE

12. ECOLOGICAL INFORMATION

AQUATIC TOXICITY ---------------------------

NO DATA AVAILABLE.

13. DISPOSAL CONSIDERATIONS

FOLLOW FEDERAL, STATE AND LOCAL REGULATIONS. RCRA HAZARDOUS WASTE. DO

NOT FLUSH TO DRAIN/ STORM SEWER. CONTRACT TO AUTHORIZED DISPOSAL SERVICE.

14. TRANSPORTATION INFORMATION

DOT-
PROPER SHIPPING NAME- FUEL OIL 1
HAZARD CLASS- 3 (FLAMMABLE LIQUID)
IDENTIFICATION NUMBER- NA1993
LABEL REQUIRED- PG III, PLACARDL FLAMMABLE LIQUID

IMDG- PROPER SHIPPING NAME- NOT AVAILABLE.

IATA- PROPER SHIPPING NAME- NOT AVAILABLE.

15. REGULATORY INFORMATION

SARA 302 THRESHOLD PLANNING QUANTITY. N/A

SARA 304 REPORTABLE QUANTITY .... N/A

SARA 311 CATEGORIES- IMMEDIATE (ACUTE) HEALTH EFFECTS.. Y
DELAYED (CHRONIC) HEALTH EFFECTS.. Y
FIRE HAZARD .... Y
SUDDEN RELEASE OF PRESSURE HAZARD. N
REACTIVITY HAZARD .... N

WHEN A COMPONENT OF THIS PRODUCT IS LISTED BELOW, THE REGULATORY LIST ON WHICH IT APPEARS IS INDICATED.

THE COMPONENTS OF THIS PRODUCT ARE LISTED ON THE EPA/TSCA INVENTORY OF CHEMICALS.

01=SARA 313
02=SARA 302/304
03=IARC CARCINOGEN
04=OSHA CARCINOGEN
05=ACGIH CARCINOGEN
06=NTP CARCINOGEN
07=CERCLA 302.4
08=WHMIS CONTROLLED PROD.
10=OTHER CARCINOGEN
PA=PENNSYLVANIA RTK
NJ=NEW JERSEY RTK
CA=CALIFORNIA PROP 65
MA=MASSACHUSETTS RTK
MI=MICHIGAN 406
MN=MINNESOTA RTK
FL=FLORIDA
RI=RHODE ISLAND
IL=ILLINOIS
NY=NEW YORK
WV=WEST VIRGINIA
CT=CONNECTICUT
LA=LOUISIANA
ME=MAINE
OH=OHIO

16. OTHER INFORMATION

DANGER] KEEP OUT OF REACH OF CHILDREN. ONLY APPROVED METAL CONTAINERS SHOULD BE USED FOR STORAGE. CONTAINERS ARE HAZARD WHEN EMPTY AS PRODUCT VAPOR OR LIQUID REMAINS. THE FOLLOWING WARNING APPLIES WHEN THIS FUEL IS BURNED IN DIESEL ENGINES: THE NATIONAL INSTITUTE OF OCCUPATIONAL SAFETY & HEALTH (NIOSH) REGARDS WHOLE DIESEL EXHAUST AS A POTENTIAL CAUSE OF OCCUPATIONAL LUNG CANCER BASED ON POSITIVEI LABORATORY STUDIES & LIMITED EVIDENCE IN HUMANS, ANY RISK WOULD DEPEND ON DURATION AND LEVEL OF

EXPOSURE.

MSDS

Canadian Centre for Occupational Health and Safety

*** IDENTIFICATION ***

RECORD NUMBER : 709194
LANGUAGE : ENGLISH
PRODUCT NAME(S) : DIESEL FUEL 2
PRODUCT IDENTIFICATION DATA : 00465
DATE OF MSDS : 1993-08-12

*** MANUFACTURER INFORMATION ***

MANUFACTURER : Texaco Refining and Marketing, Inc
ADDRESS : Post Office Box 7812
Universal City California
U.S.A. 91608
Telephone: 914-838-7204 (GENERAL MSDS ASSISTANCE) TECHNICAL INFORMATION: 914-838-7336 Fuels 512-459-6543 Chemicals 914-838-7509 Lubricants/Antifreezes
EMERGENCY TELEPHONE NO.(S) : 914-831-3400 (TRANSPORTATION EMERGENCY: Company)
800-424-9300 (TRANSPORTATION EMERGENCY: CHEMTREC)
914-831-3400 (HEALTH EMERGENCY: Company)

*** MATERIAL SAFETY DATA ***

PRODUCT CODE: 00465 Date Issued: 08/12/93 Supercedes: 05/27/92
PRODUCT NAME: DIESEL FUEL 2

TEXACO
MATERIAL SAFETY DATA SHEET

NOTE: Read and understand Material Safety Data Sheet before handling or disposing of product.
N.D. - Not Determined N.A. - Not Applicable N.T. - Not Tested
< - Less Than > - Greater Than

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATERIAL IDENTITY

Product Code and Name:
00465 DIESEL FUEL 2

Chemical Name and/or Family or Description:
Diesel Fuel

Manufacturer's Name and Address:
Texaco Refining and Marketing, Inc.
P.O. Box 7812 Universal City, California 91608

Telephone Numbers:

TRANSPORTATION EMERGENCY	Company:	(914) 831-3400
	CHEMTREC:	(800) 424-9300
HEALTH EMERGENCY	Company:	(914) 831-3400
GENERAL MSDS ASSISTANCE		(914) 838-7204
TECHNICAL INFORMATION	Fuels:	(914) 838-7336
	Chemicals:	(512) 459-6543
	Lubricants/Antifreezes:	(914) 838-7509

2. COMPOSITION/INFORMATION ON INGREDIENTS

THE CRITERIA FOR LISTING COMPONENTS IN THE COMPOSITION SECTION IS AS FOLLOWS: CHRONIC HAZARDS (CARCINOGENIC, TERATOGENIC, MUTAGENIC, NEUROTOXIC AND SENSITIZERS) ARE LISTED WHEN PRESENT AT 0.01% OR GREATER; ACUTE HAZARDS ARE LISTED WHEN PRESENT AT 1.0% OR GREATER AND NON-HAZARDOUS COMPONENTS ARE LISTED WHEN PRESENT AT 3.0% OR GREATER. THIS IS NOT INTENDED TO BE A COMPLETE COMPOSITIONAL DISCLOSURE.

Product and/or Component(s) Carcinogenic According to:

OSHA	IARC	NTP	OTHER	NONE
X	X	X	X	
-	-	-	-	-

Composition:

Chemical/Common Name	CAS No.	Range in %
A complex mixture of hydrocarbons produced by the distillation of crude oil. Consists predominantly of hydrocarbons ranging from C-9 to C-20,and boiling in the range of 325-675F. Product also contains some hydrocarbons produced by the distillation of products from a catalytic cracking process. The latter materials contain bicyclic and tricyclic aromatic hydrocarbons. The product may be hydrotreated or hydrodesulfurized. May contain on average 0.01% benzene.	N.A.	100.00

Chemical/Common Name	Exposure Limit
A complex mixture of hydrocarbons produced by the distillation of crude oil. Consists predominantly of hydrocarbons ranging from C-9 to C-20,and boiling in the range of 325-675F. Product also contains some hydrocarbons produced by the distillation of products from a catalytic cracking process. The latter materials contain bicyclic and tricyclic aromatic hydrocarbons. The product may be hydrotreated or hydrodesulfurized. May contain on average 0.01% benzene.	NONE ESTABLISHED

Product is hazardous according to OSHA (1910.1200).

3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW

Appearance and Odor:

Clear and bright liquid

WARNING STATEMENT

DANGER] CAUSES SEVERE SKIN BURNS
HARMFUL IF INHALED
MAY BE HARMFUL IF ABSORBED THROUGH SKIN
MAY CAUSE DIZZINESS AND DROWSINESS
ASPIRATION HAZARD IF SWALLOWED--CAN ENTER LUNGS AND CAUSE DAMAGE
COMBUSTIBLE LIQUID AND VAPOR
USE ONLY AS A FUEL

ATTENTION] POSSIBLE CANCER HAZARD
CONTAINS MIDDLE DISTILLATES WHICH MAY CAUSE CANCER
BASED ON ANIMAL DATA

HMIS

Health:	3	Reactivity:	0
Flammability:	2	Special:	-

NFPA

Health:	3	Reactivity:	0
Flammability:	2	Special:	-

POTENTIAL HEALTH EFFECTS

	EYE	SKIN	INHALATION	INGESTION
Primary Route of Exposure:	X	X	X	
	-	-	-	-

Effects of Overexposure

Acute

Eyes:

May cause irritation, experienced as mild discomfort and seen as slight excess redness of the eye.

Skin:

Prolonged or widespread skin contact may result in the absorption of potentially harmful amounts of material.
Causes severe irritation with pain, severe excess redness and swelling with chemical burns, blister formation, and possible tissue destruction.

Inhalation:

Vapors or mist may cause irritation of the nose and throat, headache, nausea, vomiting, dizziness, drowsiness, euphoria, loss of coordination, and disorientation. In poorly ventilated areas or confined spaces, unconsciousness and asphyxiation may result.

Ingestion:

If more than several mouthfuls are swallowed, abdominal discomfort, nausea, and diarrhea may occur. Aspiration may occur during swallowing or vomiting resulting in lung damage.

Sensitization Properties:

Unknown.

Chronic:

NIOSH has recommended that whole diesel exhaust be regarded as a potential occupational carcinogen, based on findings of carcinogenic responses in laboratory animals exposed to whole diesel exhaust. The excess cancer risk for workers exposed to diesel exhaust has not been calculated; the probability of developing cancer should be decreased by minimizing exposure to the lowest feasible limits.
Repeated skin contact may cause a persistent irritation or dermatitis.

Medical Conditions Aggravated by Exposure:

Skin contact may aggravate an existing dermatitis (skin condition).

Other Remarks:

This product contains benzene. Prolonged and repeated exposure to benzene has been associated with anemia and leukemia in humans.

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4. FIRST AID MEASURES

Eyes:

Immediately flush eyes with plenty of water for at least 15 minutes. Hold eyelids apart while flushing to rinse entire surface of eye and lids with water. Get medical attention.

Skin:

Wash skin with plenty of soap and water until all traces of material are removed. Remove and clean contaminated clothing (See Other Instructions). Destroy non-resistant footwear. Get medical attention if skin irritation persists or contact has been prolonged.

Ingestion:

If swallowed, get immediate medical attention. ONLY induce vomiting as directed by a doctor. Never give anything by mouth to an unconscious or convulsing person.

Inhalation:

Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, qualified personnel may administer oxygen. Get immediate medical attention.

Other Instructions:

Remove and dry-clean or launder clothing soaked or soiled with this material before reuse. Dry cleaning of contaminated clothing may be more effective than normal laundering. Inform individuals responsible for cleaning of potential hazards associated with handling contaminated clothing.

NOTE TO PHYSICIAN: Aspiration of this product during induced emesis can result in lung injury. If evacuation of stomach contents is considered necessary, use method least likely to cause aspiration, such as gastric lavage after endotracheal intubation.

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5. FIRE-FIGHTING MEASURES

Ignition Temp. Degrees F.: 500
Flash Point Degrees F. (Method): 160 F (PM)
Flammable Limits (%) Lower: 0.52 Upper: 4.10

Recommended Fire Extinguishing Agents And Special Procedures:

According to NFPA Guide, use water spray, dry chemical, foam, or carbon dioxide. Water or foam may cause frothing. Use water to cool fire-exposed containers. If a leak or spill has not ignited, use water spray to disperse the vapors and to provide protection for persons attempting to stop the leak.

Unusual or Explosive Hazards:

None

6. ACCIDENTAL RELEASE MEASURES

Transportation Spills Call: CHEMTREC (800) 424-9300

Procedures in Case of Accidental Release, Breakage or Leakage:

Ventilate area. Avoid breathing vapor. Use self-contained breathing apparatus or supplied air for large spills or confined areas. Contain spill if possible. Wipe up or absorb on suitable material and shovel up. Prevent entry into sewers and waterways. Avoid contact with skin, eyes or clothing.

7. HANDLING AND STORAGE

Precautions to be Taken in Handling and Storage:

Store away from heat and open flame. A placard is required only when material is contained in packaging or container that exceeds 110 gallons, or in tank car or tank truck. Transport, handle, and store in accordance with OSHA Regulation 1910.106 and applicable DOT Regulations.

Eye wash and safety shower should be available nearby when this product is handled or used.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Protective Equipment (Type)

Eye/Face Protection:

Chemical-type goggles or face shield recommended to prevent eye contact.

Skin Protection:

Protective clothing such as uniforms, coveralls or lab coats must be worn. Launder or dry-clean when soiled. Gloves resistant to chemicals and petroleum distillates required. When handling large quantities, impervious suits, gloves, and rubber boots must be worn.

Respiratory Protection:

Airborne concentrations should be kept to lowest levels possible. If vapor, mist or dust is generated, use respirator approved by MSHA or NIOSH as appropriate. Supplied air respiratory protection should be used for cleaning large spills or upon entry into tanks, vessels, or other confined spaces. See below for applicable permissible concentrations.

Ventilation:

Local exhaust ventilation recommended if generating vapor, dust, or mist. If exhaust ventilation is not available or inadequate, use MSHA or NIOSH approved respirator as appropriate.

Exposure Limit for Total Product:

None established

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor:

Clear and bright liquid

Boiling Point (Degrees F.):	650	
Specific Gravity:	0.8521	(H2O=1)
pH of undiluted product:	N.A.	
Vapor Pressure:	low	mmhg
Viscosity:	3.0 cSt @ 100 F	
Percent VOC:	100	

Vapor Density: N.D.
Solubility in Water: N.D.
Other: N.D.

10. STABILITY AND REACTIVITY

This Material Reacts Violently With:
(If Others is checked below, see comments for details)

Air	Water	Heat	Strong Oxidizers	Others	None of These
			Y		
-	-	-	-	-	-

Comments:
None

Products Evolved When Subjected to Heat or Combustion:
Toxic levels of carbon monoxide, carbon dioxide, irritating aldehydes and ketones.

	OCCUR	DO NOT OCCUR
Hazardous Polymerizations:		X
	-	-

11. TOXICOLOGICAL INFORMATION

TOXICOLOGICAL INFORMATION(ANIMAL TOXICITY DATA)

Median Lethal Dose (LD50 LC50) (Species)

Oral:
Similar product 9.0 ml/kg (rat); practically non-toxic

Inhalation:
N.D.

Dermal:
Similar product >5ml/kg (rabbit); practically non-toxic

Irritation Index, Estimation of Irritation (Species)

Skin:
Similar product 6.9/8.0 (rabbit); extremely irritating

Eyes:
Similar product >15-25/110 (rabbit); slightly irritating

Sensitization:
N.D.

Other:
Middle distillates have caused skin irritation and skin cancer in laboratory animals when repeatedly applied and left in place between applications. Studies to further evaluate the carcinogenic potential of middle distillates are currently underway. Kidney damage has also been observed in laboratory animals exposed to middle distillates. Prolonged and repeated exposure to benzene has caused anemia, lymphoma, and other cancers, in laboratory animals. Benzene has been shown to cause embryo/fetal toxicity and birth defects in laboratory animals, but only at doses which cause maternal toxicity (i.e., illness in the mother).

12. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHODS

This product (as presently constituted) has the RCRA classification of benzene toxicity and, if discarded in its present form, would have the hazardous waste number D018. Under RCRA, it is the responsibility of the user of the product to determine, at the time of disposal, whether the product meets RCRA criteria for hazardous waste. This is because product uses, transformations, mixtures, processes, etc. may change the classification to non-hazardous, or hazardous for reasons other than, or in addition to, benzene toxicity.

REMARKS
None

13. TRANSPORT INFORMATION

TRANSPORTATION

DOT:
PROPER SHIPPING NAME:
DIESEL FUEL 2
HAZARD CLASS:
Combustible liquid
IDENTIFICATION NUMBER: NA1993, PG III
LABEL REQUIRED:
NONE

IMDG:
PROPER SHIPPING NAME:
N.D.

IATA:
PROPER SHIPPING NAME:
N.D.

TDG:
PROPER SHIPPING NAME:
N.D.

14. REGULATORY INFORMATION

A. SARA TITLE III

Title III Section 302/304 Extremely Hazardous Substance:

Component	CAS No.	Percent	RQ (lbs)	TPQ (lbs)
NONE				

CERCLA Section 102(a) Hazardous Substance

Component	CAS No.	Percent	RQ (lbs)
Cumene	98828	<170ppm	5000
Benzene	71432	0.0-0.36	10

Title III Section 311 Hazard Categorization

Acute	Chronic	Fire	Pressure	Reactive	Not Applicable
X	X	X			
-	-	-	-	-	-

Title III Section 313 Toxic Chemicals

Component	CAS No.	Percent
Benzene	71432	0-0.36

B. WHMIS CLASSIFICATION
NA

C. MICHIGAN CRITICAL MATERIALS
No critical materials present

15. OTHER INFORMATION

THIS PRODUCT IS INTENDED FOR USE AS A MOTOR FUEL ONLY.

This product is not intended for use in space heaters. Do not use in agricultural sprays.

Texaco recommends that all exposures to this product be minimized by strictly adhering to recommended occupational controls procedures to avoid any potential adverse health effects.

This product may be subject to export notification(s) under TSCA section 12(b); contains 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and cumene.

WARNING] This product contains detectable amounts of benzene and toluene, which are known to the State of California to cause cancer and/or reproductive toxicity.

THE INFORMATION CONTAINED HEREIN IS BELIEVED TO BE ACCURATE. IT IS PROVIDED INDEPENDENTLY OF ANY SALE OF THE PRODUCT FOR PURPOSE OF HAZARD COMMUNICATION AS PART OF TEXACO'S PRODUCT SAFETY PROGRAM. IT IS NOT INTENDED TO CONSTITUTE PERFORMANCE INFORMATION CONCERNING THE PRODUCT. NO EXPRESS WARRANTY, OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE WITH RESPECT TO THE PRODUCT OR THE INFORMATION CONTAINED HEREIN. DATA SHEETS ARE AVAILABLE FOR ALL TEXACO PRODUCTS. YOU ARE URGED TO OBTAIN DATA SHEETS FOR ALL TEXACO PRODUCTS YOU BUY, PROCESS, USE OR DISTRIBUTE AND YOU ARE ENCOURAGED AND REQUESTED TO ADVISE THOSE WHO MAY COME IN CONTACT WITH SUCH PRODUCTS OF THE INFORMATION CONTAINED HEREIN.

TO DETERMINE APPLICABILITY OR EFFECT OF ANY LAW OR REGULATION WITH RESPECT TO THE PRODUCT, USER SHOULD CONSULT HIS LEGAL ADVISOR OR THE APPROPRIATE GOVERNMENT AGENCY. TEXACO DOES NOT UNDERTAKE TO FURNISH ADVICE ON SUCH MATTERS.

Date: 08-12-93 _ New X Revised, Supersedes: 05-27-92

Date Printed: 03-09-94

Inquiries regarding MSDS should be directed to:
Texaco Inc.
Manager, Product Safety
P.O. Box 509
Beacon, N.Y. 12508

PLEASE SEE NEXT PAGE FOR PRODUCT LABEL

16. PRODUCT LABEL

READ AND UNDERSTAND MATERIAL SAFETY DATA SHEET
BEFORE HANDLING OR DISPOSING OF PRODUCT
00465 DIESEL FUEL 2

WARNING STATEMENT

DANGER] CAUSES SEVERE SKIN BURNS
HARMFUL IF INHALED
MAY BE HARMFUL IF ABSORBED THROUGH SKIN
MAY CAUSE DIZZINESS AND DROWSINESS
ASPIRATION HAZARD IF SWALLOWED--CAN ENTER
LUNGS AND CAUSE DAMAGE
COMBUSTIBLE LIQUID AND VAPOR
USE ONLY AS A FUEL

ATTENTION] POSSIBLE CANCER HAZARD
CONTAINS MIDDLE DISTILLATES WHICH MAY CAUSE CANCER
BASED ON ANIMAL DATA

PRECAUTIONARY MEASURES

AVOID CONTACT WITH SKIN AND CLOTHING
AVOID PROLONGED BREATHING OF MIST OR VAPOR
KEEP CONTAINER CLOSED
USE WITH ADEQUATE VENTILATION
WASH THOROUGHLY AFTER HANDLING
KEEP AWAY FROM HEAT, SPARKS, AND FLAME
NEVER SYPHON BY MOUTH

FIRST AID

INGESTION:
If swallowed, get immediate medical attention. ONLY induce vomiting as directed by a doctor. Never give anything by mouth to an unconscious or convulsing person.

INHALATION:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, qualified personnel may administer oxygen. Get immediate medical attention.

EYE CONTACT:
Immediately flush eyes with plenty of water for at least 15 minutes. Hold eyelids apart while flushing to rinse entire surface of eye and lids with water. Get medical attention.

SKIN CONTACT:
Wash skin with plenty of soap and water until all traces of material are removed. Remove and clean contaminated clothing (See Other Instructions). Destroy non-resistant footwear. Get medical attention if skin irritation persists or contact has been prolonged.

NOTE TO PHYSICIAN:
Aspiration of this product during induced emesis can result in lung injury. If evacuation of stomach contents is considered necessary, use method least likely to cause aspiration, such as gastric lavage after endotracheal intubation.

FIRE

In case of fire, use foam, dry chemical, or CO2. Use water spray to keep containers cool.

Chemical/Common Name	CAS No.	Range in %
A complex mixture of hydrocarbons produced by the distillation of crude oil. Consists predominantly of hydrocarbons ranging from C-9 to C-20,and boiling in the range of 325-675F. Product also contains some hydrocarbons produced by the distillation of products from a catalytic cracking process. The latter mater-	N.A.	100.00

ials contain bicyclic and tricyclic aromatic hydrocarbons. The product may be hydrotreated or hydrodesulfurized. May contain on average 0.01% benzene.

Product is hazardous according to OSHA (1910.1200).

HMIS

Health	: 3	Reactivity	: 0
Flammability	: 2	Special	: -

NFPA

Health	: 3	Reactivity	: 0
Flammability	: 2	Special	: -

DOT Proper Shipping Name: DIESEL FUEL 2
DOT Hazardous Class : Combustible liquid

CAUTION: Misuse of empty containers can be hazardous. Empty containers can be hazardous if used to store toxic, flammable, or reactive materials. Cutting or welding of empty containers might cause fire, explosion or toxic fumes from residues. Do not pressurize or expose to open flame or heat. Keep container closed and drum bungs in place.

Manufacturer's Name: Texaco Refining and Marketing, Inc.
P.O. Box 7812 Universal City, California 91608

TRANSPORTATION EMERGENCY

Company: (914) 831-3400
CHEMTREC: (800) 424-9300

HEALTH EMERGENCY

Company: (914) 831-3400

STOCK #:32033-1
MATERIAL SAFETY DATA SHEET, Valid 8/94 - 10/94
Printed Tuesday, August 16, 1994 10:46AM

Sigma Chemical Co.
P.O. Box 14508
St. Louis, MO 63178
Phone: 314-771-5765

Aldrich Chemical Co.
1001 West St. Paul
Milwaukee, WI 53233
Phone: 414-273-3850

Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779
Phone: 516-467-0980
Emergency Phone: 516-467-3535

SECTION 1. - - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - - -

STOCK #:32033-1
PRODUCT #: H0149 NAME: HYDROCHLORIC ACID

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -

CAS #:7647-01-0

SYNONYMS

ACIDE CHLORHYDRIQUE (FRENCH) * ACIDO CLORIDRICO (ITALIAN) * ANHYDROUS HYDROCHLORIC ACID * CHLOORWATERSTOF (DUTCH) * CHLOROHYDRIC ACID * CHLOROWODOR (POLISH) * CHLORWASSERSTOFF (GERMAN) * HYDROCHLORIC ACID, SOLUTION (UN1789) (DOT) * HYDROCHLORIDE * HYDROGEN CHLORIDE (ACGIH, OSHA) * HYDROGEN CHLORIDE, ANHYDROUS (UN1050) (DOT) * HYDROGEN CHLORIDE, REFRIGERATED LIQUID (UN2186) (DOT) * MURIATIC ACID * SPIRITS OF SALT * UN1050 (DOT) * UN1789 (DOT) * UN2186 (DOT) *

SECTION 3. - - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - -

LABEL PRECAUTIONARY STATEMENTS

CORROSIVE
CAUSES BURNS.
REACTS VIOLENTLY WITH WATER.
POISON
MAY DEVELOP PRESSURE.
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
TAKE OFF IMMEDIATELY ALL CONTAMINATED CLOTHING.
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION.
DO NOT BREATHE VAPOR.

SECTION 4. - - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
ASSURE ADEQUATE FLUSHING OF THE EYES BY SEPARATING THE EYELIDS WITH FINGERS.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.
CALL A PHYSICIAN IMMEDIATELY.
WASH CONTAMINATED CLOTHING BEFORE REUSE.
DISCARD CONTAMINATED SHOES.

SECTION 5. - - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - -

EXTINGUISHING MEDIA

NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
USE WATER SPRAY TO COOL FIRE-EXPOSED CONTAINERS.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

SECTION 6. - - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - -

EVACUATE AREA.
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
COVER WITH DRY-LIME, SAND, OR SODA ASH. PLACE IN COVERED CONTAINERS USING NON-SPARKING TOOLS AND TRANSPORT OUTDOORS.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - -

REFER TO SECTION 8.

SECTION 8. - - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -

CHEMICAL SAFETY GOGGLES.
SAFETY SHOWER AND EYE BATH.
FACESHIELD (8-INCH MINIMUM).
NIOSH/MSHA-APPROVED RESPIRATOR IN NONVENTILATED AREAS AND/OR FOR EXPOSURE ABOVE THE ACGIH TLV.
MECHANICAL EXHAUST REQUIRED.
RUBBER GLOVES.
AVOID BREATHING VAPOR.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
CORROSIVE.
POISON
KEEP TIGHTLY CLOSED.
MAY DEVELOP PRESSURE.
REACTS VIOLENTLY WITH WATER.
STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - -

APPEARANCE AND ODOR
COLORLESS LIQUID
FLASHPOINT NONE
VAPOR PRESSURE: 3.23PSI 21.1 C 7.93PSI 37.7 C
VAPOR DENSITY: 1.3
SPECIFIC GRAVITY: 1.200

SECTION 10. - - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - -

INCOMPATIBILITIES
BASES
AMINES
ALKALI METALS
COPPER, COPPER ALLOYS
ALUMINUM
CORRODES STEEL
DO NOT ALLOW WATER TO ENTER CONTAINER BECAUSE OF VIOLENT REACTION.
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
TOXIC FUMES OF:
HYDROGEN CHLORIDE GAS

SECTION 11. - - - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - -

ACUTE EFFECTS
MAY BE FATAL IF INHALED, SWALLOWED, OR ABSORBED THROUGH SKIN.
CAUSES BURNS.
MATERIAL IS EXTREMELY DESTRUCTIVE TO TISSUE OF THE MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT, EYES AND SKIN.
INHALATION MAY BE FATAL AS A RESULT OF SPASM, INFLAMMATION AND EDEMA

OF THE LARYNX AND BRONCHI, CHEMICAL PNEUMONITIS AND PULMONARY EDEMA. SYMPTOMS OF EXPOSURE MAY INCLUDE BURNING SENSATION, COUGHING, WHEEZING, LARYNGITIS, SHORTNESS OF BREATH, HEADACHE, NAUSEA AND VOMITING.

RTECS NO: MW4025000

HYDROCHLORIC ACID

IRRITATION DATA

EYE-RBT 5 MG/30S RINSE MLD	TXCYAC 23,281,82

TOXICITY DATA

IHL-HMN LCLO:1300 PPM/30M	29ZWAE -,207,68
IHL-HMN LCLO:3000 PPM/5M	TABIA2 3,231,33
UNR-MAN LDLO:81 MG/KG	85DCAI 2,73,70
IHL-RAT LC50:3124 PPM/1H	AMRL** TR-74-78,74
IHL-MUS LC50:1108 PPM/1H	JCTODH 3,61,76
IPR-MUS LD50:1449 MG/KG	COREAF 256,1043,63
ORL-RBT LD50:900 MG/KG	BIZEA2 134,437,23

TARGET ORGAN DATA

SENSE ORGANS AND SPECIAL SENSES (OTHER EYE EFFECTS)
LUNGS, THORAX OR RESPIRATION (RESPIRATORY STIMULATION)
SKIN AND APPENDAGES (AFTER SYSTEMIC EXPOSURE: DERMATITIS, OTHER)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - - -

FOR SMALL QUANTITIES: CAUTIOUSLY ADD TO A LARGE STIRRED EXCESS OF WATER. ADJUST THE PH TO NEUTRAL, SEPARATE ANY INSOLUBLE SOLIDS OR LIQUIDS AND PACKAGE THEM FOR HAZARDOUS-WASTE DISPOSAL. FLUSH THE AQUEOUS SOLUTION DOWN THE DRAIN WITH PLENTY OF WATER. THE HYDROLYSIS AND NEUTRALIZATION REACTIONS MAY GENERATE HEAT AND FUMES WHICH CAN BE CONTROLLED BY THE RATE OF ADDITION.

OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - - -

CONTACT SIGMA CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - - -

REVIEWS, STANDARDS, AND REGULATIONS

ACGIH TLV-CL 5 PPM	85INA8 6,773,91
IARC CANCER REVIEW:HUMAN INADEQUATE EVIDENCE	IMEMDT 54,189,92
IARC CANCER REVIEW:ANIMAL INADEQUATE EVIDENCE	IMEMDT 54,189,92
IARC CANCER REVIEW:GROUP 3	IMEMDT 54,189,92

EPA FIFRA 1988 PESTICIDE SUBJECT TO REGISTRATION OR RE-REGISTRATION
FEREAC 54,7740,89
MSHA STANDARD:AIR-CL 5 PPM (7 MG/M3)
DTLVS* 3,129,71
OSHA PEL:CL 5 PPM (7 MG/M3)
FEREAC 54,2923,89
OSHA PEL FINAL:CL 5 PPM (7 MG/M3)
FEREAC 54,2923,89
OEL-AUSTRALIA:TWA 5 PPM (7 MG/M3) JAN93
OEL-AUSTRIA:TWA 5 PPM (7 MG/M3) JAN93
OEL-BELGIUM:STEL 5 PPM (7.7 MG/M3) JAN93
OEL-DENMARK:STEL 5 PPM (7 MG/M3) JAN93
OEL-FINLAND:STEL 5 PPM (7 MG/M3);SKIN JAN93

OEL-FRANCE:STEL 5 PPM (7.5 MG/M3) JAN93
OEL-GERMANY:TWA 5 PPM (7 MG/M3) JAN93
OEL-HUNGARY:STEL 5 MG/M3 JAN93
OEL-JAPAN:STEL 5 PPM (7.5 MG/M3) JAN93
OEL-THE NETHERLANDS:TWA 5 PPM (7 MG/M3) JAN93
OEL-THE PHILIPPINES:TWA 5 PPM (7 MG/M3) JAN93
OEL-POLAND:TWA 5 MG/M3 JAN93
OEL-RUSSIA:STEL 5 PPM (5 MG/M3) JAN93
OEL-SWEDEN:STEL 5 PPM (8 MG/M3) JAN93
OEL-SWITZERLAND:TWA 5 PPM (7.5 MG/M3);STEL 10 PPM (15 MG/M3) JAN93
OEL-THAILAND:TWA 5 PPM (7 MG/M3) JAN93
OEL-TURKEY:TWA 5 PPM (7 MG/M3) JAN93
OEL-UNITED KINGDOM:TWA 5 PPM (7 MG/M3);STEL 5 PPM (7 MG/M3) JAN93
OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA CHECK ACGIH TLV
OEL IN NEW ZEALAND, SINGAPORE, VIETNAM CHECK ACGIH TLV
NIOSH REL TO HYDROGEN CHLORIDE-AIR:CL 5 PPM
NIOSH* DHHS #92-100,92
NOHS 1974: HZD 38580; NIS 360; TNF 87434; NOS 156; TNE 824985
NOES 1983: HZD 38580; NIS 315; TNF 55933; NOS 182; TNE 1184443; TFE 376404
EPA GENETOX PROGRAM 1988, NEGATIVE: CELL TRANSFORM.-SA7/SHE
EPA TSCA CHEMICAL INVENTORY, JUNE 1993
EPA TSCA SECTION 8(E) STATUS REPORT 8EHQ-0578-0146
ON EPA IRIS DATABASE
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 1994
NIOSH ANALYTICAL METHODS: SEE ACIDS, INORGANIC, 7903
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

SECTION 16. - - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - -

PRODUCT #: 36974-8 NAME: LEAD, INGOT, 99.995%
MATERIAL SAFETY DATA SHEET, Valid 8/94 - 10/94
Printed Tuesday, August 16, 1994 11:08AM

Sigma Chemical Co.
P.O. Box 14508
St. Louis, MO 63178
Phone: 314-771-5765

Aldrich Chemical Co.
1001 West St. Paul
Milwaukee, WI 53233
Phone: 414-273-3850

Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779
Phone: 516-467-0980
Emergency Phone: 516-467-3535

SECTION 1. - - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - - -

PRODUCT #: 36974-8 NAME: LEAD, INGOT, 99.995%

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -

CAS #:7439-92-1
MF: PB

SYNONYMS

C.I. PIGMENT METAL 4 * C.I. 77575 * GLOVER * KS-4 * LEAD (ACGIH) * LEAD FLAKE * LEAD INORGANIC (OSHA) * LEAD S2 * OLOW (POLISH) * OMAHA * OMAHA & GRANT * SI * SO *

SECTION 3. - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - -

LABEL PRECAUTIONARY STATEMENTS

HARMFUL
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
REPRODUCTIVE HAZARD.
TARGET ORGAN(S):
BLOOD, KIDNEYS
NERVES
WEAR SUITABLE PROTECTIVE CLOTHING.
DO NOT BREATHE DUST.
IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).
KEEP CONTAINER TIGHTLY CLOSED.

SECTION 4. - - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES.
FLUSH SKIN WITH WATER.
IF INHALED, REMOVE TO FRESH AIR.

SECTION 5. - - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - -

EXTINGUISHING MEDIA

USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

SECTION 6. - - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - -

CHEMICAL SAFETY GOGGLES.
USE PROTECTIVE CLOTHING, GLOVES AND MASK.
SWEEP UP, PLACE IN A BAG AND HOLD FOR WASTE DISPOSAL.

SECTION 7. - - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - -

REFER TO SECTION 8.

ADDITIONAL INFORMATION

VIOLENT REACTON OF LEAD WITH AMMONIUM NITRATE, HYDROGEN PEROXIDE, SODIUM AZIDE, ZIRCONIUM, SODIUM ACETYLIDE AND CHLORINE TRIFLUORIDE HAVE BEEN REPORTED.

SECTION 8. - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -

CHEMICAL SAFETY GOGGLES.

NIOSH/MSHA-APPROVED RESPIRATOR IN NONVENTILATED AREAS AND/OR FOR EXPOSURE ABOVE THE ACGIH TLV.
COMPATIBLE CHEMICAL-RESISTANT GLOVES.
SAFETY SHOWER AND EYE BATH.
MECHANICAL EXHAUST REQUIRED.
AVOID CONTACT AND INHALATION.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
REPRODUCTIVE HAZARD.
HARMFUL SOLID.
KEEP CONTAINER CLOSED.

SECTION 9. - - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - - -

DATA NOT AVAILABLE

SECTION 10. - - - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - - - -

INCOMPATIBILITIES
STRONG ACIDS
HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
NATURE OF DECOMPOSITION PRODUCTS NOT KNOWN.

SECTION 11. - - - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - - - -

ACUTE EFFECTS
HARMFUL IF INHALED OR SWALLOWED.
MAY CAUSE IRRITATION.
MAY CAUSE NERVOUS SYSTEM DISTURBANCES.
CHRONIC EFFECTS
MAY CAUSE REPRODUCTIVE DISORDERS.
ANEMIA
TARGET ORGAN(S):
NERVES
BLOOD, KIDNEYS
FEMALE REPRODUCTIVE SYSTEM
MALE REPRODUCTIVE SYSTEM
RTECS NO: OF7525000
LEAD
TARGET ORGAN DATA
PERIPHERAL NERVE AND SENSATION (FLACCID PARALYSIS WITHOUT ANESTHESIA)
BEHAVIORAL (HALLUCINATIONS, DISTORTED PERCEPTIONS)
BEHAVIORAL (MUSCLE WEAKNESS)
GASTROINTESTINAL (GASTRITIS)
LIVER (OTHER CHANGES)
EFFECTS ON FERTILITY (OTHER MEASURES OF FERTILITY)
EFFECTS ON EMBRYO OR FETUS (FETOTOXICITY)
EFFECTS ON EMBRYO OR FETUS (FETAL DEATH)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (BLOOD AND LYMPHATIC SYSTEMS)
EFFECTS ON NEWBORN (GROWTH STATISTICS)
EFFECTS ON NEWBORN (BIOCHEMICAL AND METABOLIC)
EFFECTS ON NEWBORN (BEHAVIORAL)
ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - - -

MATERIAL IN THE ELEMENTAL STATE SHOULD BE RECOVERED FOR REUSE OR RECYCLING.

OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - -

CONTACT ALDRICH CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - - -

REVIEWS, STANDARDS, AND REGULATIONS

ACGIH TLV-TWA 0.15 MG/M3	85INA8 6,847,91
IARC CANCER REVIEW:ANIMAL INADEQUATE EVIDENCE	IMEMDT 23,325,80
IARC CANCER REVIEW:HUMAN INADEQUATE EVIDENCE	IMEMDT 23,325,80
IARC CANCER REVIEW:GROUP 2B	IMSUDL 7,230,87

MSHA STANDARD-AIR:TWA 0.15 MG/M3 DTLVS* 3,143,71

OSHA PEL:8H TWA 0.05 MG(PB)/M3 FEREAC 43,53007,78

OEL-FRANCE:TWA 150 MG/M3 JAN93

OEL-GERMANY:TWA 0.1 MG/M3 JAN93

OEL-POLAND:TWA 0.05 MG/M3 JAN93

NIOSH REL TO LEAD, INORGANIC-AIR:10H TWA <0.1 MG(PB)/M3 NIOSH* DHHS #92-100,92

NOHS 1974: HZD 42490; NIS 107; TNF 8256; NOS 81; TNE 103308

NOES 1983: HZD X5909; NIS 4; TNF 53; NOS 7; TNE 857; TFE 437

NOES 1983: HZD 42490; NIS 234; TNF 41942; NOS 146; TNE 743992; TFE 235080

EPA GENETOX PROGRAM 1988, POSITIVE: SPERM MORPHOLOGY-HUMAN

EPA GENETOX PROGRAM 1988, NEGATIVE: IN VIVO CYTOGENETICS-NONHUMAN BONE MARROW

EPA GENETOX PROGRAM 1988, NEGATIVE: IN VITRO CYTOGENETICS-HUMAN LYMPHOCYTE

EPA GENETOX PROGRAM 1988, INCONCLUSIVE: CARCINOGENICITY-MOUSE/RAT

EPA GENETOX PROGRAM 1988, INCONCLUSIVE: IN VIVO CYTOGENETICS-HUMAN LYMPHOCYTE

EPA TSCA CHEMICAL INVENTORY, JUNE 1993

EPA TSCA SECTION 8(E) STATUS REPORT 8EHQ-0680-0345

EPA TSCA SECTION 8(E) STATUS REPORT 8EHQ-0285-0546;8EHQ-0286-0588;8EHQ-0586-0601

ON EPA IRIS DATABASE

EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 1994

NIOSH ANALYTICAL METHODS: SEE LEAD, 7082; ELEMENTS, 7300; LEAD IN BLOOD AND URINE, 8003

NIOSH ANALYTICAL METHODS: SEE LEAD (AA-FLAME) 7082 OR (AA-FLAMELESS) 7105

NIOSH ANALYTICAL METHODS: SEE ELEMENTS IN BLOOD OR TISSUE 8005

NIOSH ANALYTICAL METHODS: SEE LEAD IN BLOOD AND URINE 8003

NIOSH ANALYTICAL METHODS: SEE METALS IN URINE (ICP) 8310

OSHA ANALYTICAL METHOD #ID-125G

THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

SECTION 16. - - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - -

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. SIGMA, ALDRICH, FLUKA SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

STOCK #:25811-3
MATERIAL SAFETY DATA SHEET, Valid 8/94 - 10/94
Printed Tuesday, August 16, 1994 10:49AM

Sigma Chemical Co.
P.O. Box 14508
St. Louis, MO 63178
Phone: 314-771-5765

Aldrich Chemical Co.
1001 West St. Paul
Milwaukee, WI 53233
Phone: 414-273-3850

Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779
Phone: 516-467-0980
Emergency Phone: 516-467-3535

SECTION 1. - - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - - -

STOCK #:25811-3
PRODUCT #: N9271 NAME: NITRIC ACID

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -

CAS #:7697-37-2

SYNONYMS

ACIDE NITRIQUE (FRENCH) * ACIDO NITRICO (ITALIAN) * AQUA FORTIS * AZOTIC ACID * AZOTOWY KWAS (POLISH) * HYDROGEN NITRATE * KYSELINA DUSICNE (CZECH) * NITRIC ACID (ACGIH,OSHA) * NITRIC ACID OTHER THAN RED FUMING WITH >70% NITRIC ACID (DOT) * NITRIC ACID OTHER THAN RED FUMING WITH NOT >70% NITRIC ACID (DOT) * SALPETERSAURE (GERMAN) * SALPETERZUUROPLOSSINGEN (DUTCH) * UN2031 (DOT) *

SECTION 3. - - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - - -

LABEL PRECAUTIONARY STATEMENTS

OXIDIZING
HIGHLY TOXIC (USA DEFINITION)
TOXIC (EUROPEAN DEFINITION)
CONTACT WITH COMBUSTIBLE MATERIAL MAY CAUSE FIRE.
TOXIC BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
CAUSES BURNS.
REACTS VIOLENTLY WITH WATER.
KEEP AWAY FROM COMBUSTIBLE MATERIAL.
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
TAKE OFF IMMEDIATELY ALL CONTAMINATED CLOTHING.
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION.

SECTION 4. - - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
ASSURE ADEQUATE FLUSHING OF THE EYES BY SEPARATING THE EYELIDS WITH FINGERS.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN IMMEDIATELY.
DISCARD CONTAMINATED CLOTHING AND SHOES.

SECTION 5. - - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - -

EXTINGUISHING MEDIA

NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.
DO NOT USE WATER.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
REACTS VIOLENTLY WITH WATER.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

STRONG OXIDIZER.
CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE.
VIGOROUSLY SUPPORTS COMBUSTION.
EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

SECTION 6. - - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - -

WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
ABSORB ON SAND OR VERMICULITE AND PLACE IN CLOSED CONTAINERS FOR DISPOSAL.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - -

REFER TO SECTION 8.

SECTION 8. - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -

CHEMICAL SAFETY GOGGLES.
SAFETY SHOWER AND EYE BATH.
RUBBER APRON.
NIOSH/MSHA-APPROVED RESPIRATOR.
WEAR HEAVY RUBBER GLOVES.
MECHANICAL EXHAUST REQUIRED.
FACESHIELD (8-INCH MINIMUM).
AVOID CONTACT AND INHALATION.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
POISON
CORROSIVE.
KEEP TIGHTLY CLOSED.
DO NOT STORE NEAR, NOR ALLOW CONTACT WITH, CLOTHING AND OTHER COMBUSTIBLE MATERIAL.
PROTECT FROM LIGHT.
DO NOT ALLOW CONTACT WITH WATER.
STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - -

APPEARANCE AND ODOR

LIQUID.
FLASHPOINT NONE
VAPOR PRESSURE: 8MM 20 C
VAPOR DENSITY: 1
SPECIFIC GRAVITY: 1.400

SECTION 10. - - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - -

INCOMPATIBILITIES

BASES
REDUCING AGENTS
ALCOHOLS
ALKALI METALS
BRASS
FINELY POWDERED METALS
COPPER, COPPER ALLOYS
GALVANIZED IRON
ALUMINUM
CORRODES STEEL
ORGANIC MATERIALS
AMINES
MAY DISCOLOR ON EXPOSURE TO LIGHT.

REACTS VIOLENTLY WITH:
WATER

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
TOXIC FUMES OF:
NITROGEN OXIDES

SECTION 11. - - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - -

ACUTE EFFECTS
MAY BE FATAL IF INHALED, SWALLOWED, OR ABSORBED THROUGH SKIN.
CAUSES BURNS.
MATERIAL IS EXTREMELY DESTRUCTIVE TO TISSUE OF THE MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT, EYES AND SKIN.
INHALATION MAY BE FATAL AS A RESULT OF SPASM, INFLAMMATION AND EDEMA OF THE LARYNX AND BRONCHI, CHEMICAL PNEUMONITIS AND PULMONARY EDEMA.
SYMPTOMS OF EXPOSURE MAY INCLUDE BURNING SENSATION, COUGHING, WHEEZING, LARYNGITIS, SHORTNESS OF BREATH, HEADACHE, NAUSEA AND VOMITING.

RTECS NO: QU5775000
NITRIC ACID

TOXICITY DATA

ORL-HMN LDLO:430 MG/KG	YAKUD5 22,651,80
UNR-MAN LDLO:110 MG/KG	85DCAI 2,73,70

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - -

FOR SMALL QUANTITIES: CAUTIOUSLY ADD TO A LARGE STIRRED EXCESS OF WATER. ADJUST THE PH TO NEUTRAL, SEPARATE ANY INSOLUBLE SOLIDS OR LIQUIDS AND PACKAGE THEM FOR HAZARDOUS-WASTE DISPOSAL. FLUSH THE AQUEOUS SOLUTION DOWN THE DRAIN WITH PLENTY OF WATER. THE HYDROLYSIS AND NEUTRALIZATION REACTIONS MAY GENERATE HEAT AND FUMES WHICH CAN BE CONTROLLED BY THE RATE OF ADDITION.
OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - - -

CONTACT SIGMA CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - -

REVIEWS, STANDARDS, AND REGULATIONS
ACGIH TLV-TWA 2 PPM; STEL 4 PPM 85INA8 6,1088,91
MSHA STANDARD-AIR:TWA 2 PPM (5 MG/M3)
DTLVS* 3,181,71
OSHA PEL:8H TWA 2 PPM (5 MG/M3)
FEREAC 54,2923,89
OSHA PEL FINAL:8H TWA 2 PPM (5 MG/M3);STEL 4 PPM (10 MG/M3)
FEREAC 54,2923,89
OEL-ARAB REPUBLIC OF EGYPT:TWA 2 PPM (5 MG/M3) JAN93
OEL-AUSTRALIA:TWA 2 PPM (5 MG/M3);STEL 4 PPM (10 MG/M3) JAN93
OEL-BELGIUM:TWA 2 PPM (5.2 MG/M3);STEL 4 PPM (10 MG/M3) JAN93
OEL-CZECHOSLOVAKIA:TWA 2.5 MG/M3;STEL 5 MG/M3 JAN93
OEL-DENMARK:TWA 2 PPM (5 MG/M3) JAN93
OEL-FINLAND:TWA 2 PPM (5 MG/M3);STEL 5 PPM (13 MG/M3);SKIN JAN93
OEL-FRANCE:TWA 2 PPM (5 MG/M3);STEL 4 PPM (10 MG/M3) JAN93
OEL-GERMANY:TWA 10 PPM (25 MG/M3) JAN93
OEL-HUNGARY:STEL 5 MG/M3 JAN93

OEL-JAPAN:TWA 2 PPM (5.2 MG/M3) JAN93
OEL-THE PHILIPPINES:TWA 2 PPM (5 MG/M3) JAN93
OEL-POLAND:TWA 10 MG/M3 JAN93
OEL-RUSSIA:TWA 2 PPM;STEL 2 MG/M3;SKIN JAN93
OEL-SWEDEN:TWA 2 PPM (5 MG/M3);STEL 5 PPM (13 MG/M3) JAN93
OEL-SWITZERLAND:TWA 2 PPM (5 MG/M3);STEL 4 PPM (10 MG/M3) JAN93
OEL-THAILAND:TWA 2 PPM (5 MG/M3) JAN93
OEL-TURKEY:TWA 2 PPM (5 MG/M3) JAN93
OEL-UNITED KINGDOM:TWA 2 PPM (5 MG/M3);STEL 4 PPM (10 MG/M3) JAN93
OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA CHECK ACGIH TLV
OEL IN NEW ZEALAND, SINGAPORE, VIETNAM CHECK ACGIH TLV
NIOSH REL TO NITRIC ACID-AIR:10H TWA 2 PPM;STEL 4 PPM
NIOSH* DHHS #92-100,92
NOHS 1974: HZD 50742; NIS 197; TNF 18088; NOS 101; TNE 132401
NOES 1983: HZD 50742; NIS 196; TNF 17714; NOS 117; TNE 285885; TFE 74869
EPA GENETOX PROGRAM 1988, NEGATIVE: CELL TRANSFORM.-SA7/SHE
EPA TSCA CHEMICAL INVENTORY, JUNE 1993
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 1994
NIOSH ANALYTICAL METHODS: SEE ACIDS, INORGANIC, 7903
OSHA ANALYTICAL METHOD #ID-127
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

SECTION 16. - - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - - -

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. SIGMA, ALDRICH, FLUKA SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

PRODUCT #: 89681 NAME: TOLUENE
MATERIAL SAFETY DATA SHEET, Valid 8/94 - 10/94
Printed Tuesday, August 16, 1994 10:52AM

Sigma Chemical Co.	Aldrich Chemical Co.	Fluka Chemical Corp.
P.O. Box 14508	1001 West St. Paul	980 South Second St.
St. Louis, MO 63178	Milwaukee, WI 53233	Ronkonkoma, NY 11779
Phone: 314-771-5765	Phone: 414-273-3850	Phone: 516-467-0980
		Emergency Phone: 516-467-3535

SECTION 1. - - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - - -

PRODUCT #: 89681 NAME: TOLUENE

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -

CAS #:108-88-3

SYNONYMS

ANTISAL 1A * BENZENE, METHYL- * METHACIDE * METHANE, PHENYL- * METHYLBENZENE * METHYLBENZOL * NCI-C07272 * PHENYLMETHANE * RCRA WASTE NUMBER U220 * TOLUEEN (DUTCH) * TOLUEN (CZECH) * TOLUENE (ACGIH, DOT,OSHA) * TOLUENO (SPANISH) * TOLUOL * TOLUOLO (ITALIAN) * TOLU-SOL * UN1294 (DOT) *

SECTION 3. - - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - -

LABEL PRECAUTIONARY STATEMENTS

FLAMMABLE (USA DEFINITION)
HIGHLY FLAMMABLE (EUROPEAN DEFINITION)
TOXIC
TOXIC BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
CAUSES SEVERE IRRITATION.
TARGET ORGAN(S):
LIVER, KIDNEYS
BRAIN
BLADDER
KEEP AWAY FROM SOURCES OF IGNITION. NO SMOKING.
IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
AFTER CONTACT WITH SKIN, WASH IMMEDIATELY WITH PLENTY OF WATER.
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION.

SECTION 4. - - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

SECTION 5. - - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - -

EXTINGUISHING MEDIA

CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.
WATER MAY BE EFFECTIVE FOR COOLING, BUT MAY NOT EFFECT EXTINGUISHMENT.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
USE WATER SPRAY TO COOL FIRE-EXPOSED CONTAINERS.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

DANGER:
EXTREMELY FLAMMABLE.
VAPOR MAY TRAVEL CONSIDERABLE DISTANCE TO SOURCE OF IGNITION AND FLASH BACK.
CONTAINER EXPLOSION MAY OCCUR UNDER FIRE CONDITIONS.

SECTION 6. - - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - - -

EVACUATE AREA.
SHUT OFF ALL SOURCES OF IGNITION.
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
COVER WITH AN ACTIVATED CARBON ADSORBENT, TAKE UP AND PLACE IN CLOSED CONTAINERS. TRANSPORT OUTDOORS.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - - -

REFER TO SECTION 8.

ADDITIONAL INFORMATION

IRON OR FERRIC CHLORIDE CATALYZES A VIGOROUS EXOTHERMIC REACTION BETWEEN TOLUENE AND SULFUR DICHLORIDE. REF: CHEM. ENG. NEWS, P.2, AUGUST 8, 1988.

SECTION 8. - - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
DO NOT BREATHE VAPOR.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
READILY ABSORBED THROUGH SKIN.
WASH THOROUGHLY AFTER HANDLING.
TOXIC.
SEVERE IRRITANT.
KEEP TIGHTLY CLOSED.
KEEP AWAY FROM HEAT, SPARKS, AND OPEN FLAME.
STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - -

APPEARANCE AND ODOR

COLORLESS LIQUID
BOILING POINT: 110.6 C
MELTING POINT: -93 C
FLASHPOINT 40 F
4C
AUTOIGNITION TEMPERATURE: 997 F 535C
UPPER EXPLOSION LEVEL: 7%
LOWER EXPLOSION LEVEL: 1%
VAPOR PRESSURE: 22MM 20 C 26MM 25 C
VAPOR DENSITY: 3.2
SPECIFIC GRAVITY: 0.865

SECTION 10. - - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - -

INCOMPATIBILITIES

OXIDIZING AGENTS
PROTECT FROM MOISTURE.

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS

TOXIC FUMES OF:
CARBON MONOXIDE, CARBON DIOXIDE

SECTION 11. - - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - -

ACUTE EFFECTS

HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
CAUSES SEVERE IRRITATION.
HIGH CONCENTRATIONS ARE EXTREMELY DESTRUCTIVE TO TISSUES OF THE MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT, EYES AND SKIN.
SYMPTOMS OF EXPOSURE MAY INCLUDE BURNING SENSATION, COUGHING, WHEEZING, LARYNGITIS, SHORTNESS OF BREATH, HEADACHE, NAUSEA AND VOMITING.
EXPOSURE CAN CAUSE:
LUNG IRRITATION, CHEST PAIN AND EDEMA WHICH MAY BE FATAL.

CHRONIC EFFECTS

MAY CAUSE NERVOUS SYSTEM DISTURBANCES.
INHALATION STUDIES ON TOLUENE HAVE DEMONSTRATED THE DEVELOPMENT OF INFLAMMATORY AND ULCEROUS LESIONS OF THE PENIS, PREPUCE AND SCROTUM IN ANIMALS.
TARGET ORGAN(S):
BRAIN
LIVER
KIDNEYS
BLADDER

ADDITIONAL INFORMATION

EXPOSURE TO AND/OR CONSUMPTION OF ALCOHOL
MAY INCREASE TOXIC EFFECTS.

RTECS NO: XS5250000
TOLUENE

IRRITATION DATA

EYE-HMN 300 PPM	JIHTAB 25,282,43
SKN-RBT 435 MG MLD	UCDS** 7/23/70
SKN-RBT 500 MG MOD	FCTOD7 20,563,82
SKN-RBT 20 MG/24H MOD	85JCAE -,29,86
EYE-RBT 870 UG MLD	UCDS** 7/23/70
EYE-RBT 2 MG/24H SEV	85JCAE -,29,86
EYE-RBT 100 MG/30S RINSE MLD	FCTOD7 20,573,82

TOXICITY DATA

ORL-HMN LDLO:50 MG/KG	YAKUD5 22,883,80
ORL-RAT LD50:636 MG/KG	NRTXDN 2,567,81
IHL-RAT LC50:289 GM/M3	SRTCAC 36(1-4),10,89
IPR-RAT LD50:1332 MG/KG	ENVRAL 40,411,86
IVN-RAT LD50:1960 MG/KG	MELAAD 54,486,63
UNR-RAT LD50:6900 MG/KG	GISAAA 45(12),64,80
IHL-MUS LC50:400 PPM/24H	NRTXDN 2,567,81
IPR-MUS LD50:59 MG/KG	NRTXDN 2,567,81
SCU-MUS LD50:2250 MG/KG	NRTXDN 8,237,87
UNR-MUS LD50:2 GM/KG	GISAAA 45(12),64,80
SKN-RBT LD50:12124 MG/KG	AIHAAP 30,470,69
IPR-GPG LD50:500 MG/KG	NRTXDN 2,567,81
ORL-MAM LD50:4 GM/KG	GTPZAB 32(10),25,88
IHL-MAM LC50:30 GM/M3	GTPZAB 32(10),25,88

TARGET ORGAN DATA

BRAIN AND COVERINGS (RECORDINGS FROM SPECIFIC AREAS OF CNS)
AUTONOMIC NERVOUS SYSTEM (OTHER: PARASYMPATHOMIMETIC)
BEHAVIORAL (GENERAL ANESTHETIC)
BEHAVIORAL (SOMNOLENCE)

BEHAVIORAL (HALLUCINATIONS, DISTORTED PERCEPTIONS)
BEHAVIORAL (CONVULSIONS OR EFFECT ON SEIZURE THRESHOLD)
BEHAVIORAL (CHANGE IN MOTOR ACTIVITY)
BEHAVIORAL (MUSCLE CONTRACTION OR SPASTICITY)
BEHAVIORAL (ANTIPSYCHOTIC)
BEHAVIORAL (IRRITABILITY)
BEHAVIORAL (CHANGE IN PSYCHOPHYSIOLOGICAL TESTS)
LUNGS, THORAX OR RESPIRATION (OTHER CHANGES)
BLOOD (CHANGES IN BONE MARROW NOT INCLUDED IN ABOVE)
EFFECTS ON FERTILITY (ABORTION)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (MUSCULOSKELETAL SYSTEM)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (UROGENITAL SYSTEM)
EFFECTS ON NEWBORN (BIOCHEMICAL AND METABOLIC)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - -

BURN IN A CHEMICAL INCINERATOR EQUIPPED WITH AN AFTERBURNER AND SCRUBBER BUT EXERT EXTRA CARE IN IGNITING AS THIS MATERIAL IS HIGHLY FLAMMABLE.

OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - -

CONTACT FLUKA CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - -

REVIEWS, STANDARDS, AND REGULATIONS

ACGIH TLV-TWA 50 PPM (SKIN) 85INA8 6,1568,91
IARC CANCER REVIEW:ANIMAL INADEQUATE EVIDENCE IMEMDT 47,79,89
IARC CANCER REVIEW:HUMAN INADEQUATE EVIDENCE IMEMDT 47,79,89
IARC CANCER REVIEW:GROUP 3 IMEMDT 47,79,89
MSHA STANDARD-AIR:TWA 100 PPM (375 MG/M3) (SKIN)
DTLWS* 3,29,73
OSHA PEL:8H TWA 200 PPM;CL 300;PK 500/10M
FEREAC 54,2923,89
OSHA PEL FINAL:8H TWA 100 PPM (375 MG/M3);STEL 150 PPM (560 MG/M3)
FEREAC 54,2923,89
OEL-AUSTRALIA:TWA 100 PPM (375 MG/M3);STEL 150 PPM (560 MG/M3) JAN93
OEL-BELGIUM:TWA 100 PPM (377 MG/M3);STEL 150 PPM (565 MG/M3) JAN93
OEL-CZECHOSLOVAKIA:TWA 200 MG/M3;STEL 1000 MG/M3 JAN93
OEL-DENMARK:TWA 50 PPM (190 MG/M3);SKIN JAN93
OEL-FINLAND:TWA 100 PPM (375 MG/M3);STEL 150 PPM;SKIN JAN93
OEL-FRANCE:TWA 100 PPM (375 MG/M3);STEL 150 PPM (560 MG/M3) JAN93
OEL-GERMANY:TWA 100 PPM (380 MG/M3) JAN93
OEL-HUNGARY:TWA 100 MG/M3;STEL 300 MG/M3;SKIN JAN93
OEL-JAPAN:TWA 100 PPM (380 MG/M3) JAN93
OEL-THE NETHERLANDS:TWA 100 PPM (375 MG/M3);SKIN JAN93
OEL-THE PHILIPPINES:TWA 100 PPM (375 MG/M3) JAN93
OEL-POLAND:TWA 100 MG/M3 JAN93
OEL-RUSSIA:TWA 100 PPM;STEL 50 MG/M3 JAN93
OEL-SWEDEN:TWA 50 PPM (200 MG/M3);STEL 100 PPM (400 MG/M3);SKIN JAN93
OEL-SWITZERLAND:TWA 100 PPM (380 MG/M3);STEL 500 PPM JAN93
OEL-THAILAND:TWA 200 PPM;STEL 300 PPM JAN93
OEL-TURKEY:TWA 200 PPM (750 MG/M3) JAN93

OEL-UNITED KINGDOM:TWA 100 PPM (375 MG/M3);STEL 150 PPM;SKIN JAN93
OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA CHECK ACGIH TLV
OEL IN NEW ZEALAND, SINGAPORE, VIETNAM CHECK ACGIH TLV
NIOSH REL TO TOLUENE-AIR:10H TWA 100 PPM;STEL 150 PPM
NIOSH* DHHS #92-100,92
NOHS 1974: HZD 73300; NIS 412; TNF 125516; NOS 206; TNE 1589482
NOES 1983: HZD 73300; NIS 395; TNF 118968; NOS 227; TNE 1788619; TFE 315879
ATSDR TOXICOLOGY PROFILE (NTIS** PB/90/198904/AS)
EPA GENETOX PROGRAM 1988, NEGATIVE: CELL TRANSFORM.-SA7/SHE; IN VITRO SCE-HUMAN
EPA GENETOX PROGRAM 1988, NEGATIVE: SPERM MORPHOLOGY-MOUSE
EPA GENETOX PROGRAM 1988, INCONCLUSIVE: E COLI POLA WITHOUT S9
EPA TSCA CHEMICAL INVENTORY, JUNE 1993
EPA TSCA 8(A) PRELIMINARY ASSESSMENT INFORMATION, FINAL RULE FEREAC 47,26992,82
EPA TSCA SECTION 8(E) STATUS REPORT 8EHQ-0680-0345;8EHQ-1080-0368;8EHQ-0278-0079 P
ON EPA IRIS DATABASE
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 1994
NIOSH ANALYTICAL METHODS: SEE HYDROCARBONS, AROMATIC, 1501; HYDROCARBONS, BP 36-126 C, 1500;
NIOSH ANALYTICAL METHODS: SEE TOLUENE, 4000; 2-BUTANONE, ETHANOL, AND TOLUENE IN BLOOD, 8002
NIOSH ANALYTICAL METHODS: SEE HYDROCARBONS, BP 36-126 DEGREE C 1500
NIOSH ANALYTICAL METHODS: SEE HYDROCARBONS, AROMATIC 1501
NTP CARCINOGENESIS STUDIES (INHALATION);NO EVIDENCE:RAT,MOUSE NTPTR* NTP-TR-371,90
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

SECTION 16. - - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - -

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. SIGMA, ALDRICH, FLUKA SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

OHS24509

SECTION 1 CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

OCCUPATIONAL HEALTH SERVICES, INC.
11 WEST 42ND STREET, 12TH FLOOR
NEW YORK, NEW YORK 10036
1-800-445-MSDS (1-800-445-6737) OR
1-212-789-3535

FOR EMERGENCY SOURCE INFORMATION
CONTACT: 1-615-366-2000 USA

CAS NUMBER: 14940-65-9

SUBSTANCE: TRITIATED WATER

TRADE NAMES/SYNONYMS:
WATER-T2; WATER, HEAVY (T2O); HEAVY WATER (T2O); TRITIUM OXIDE; TRITIUM OXIDE-T2; TRITIUM OXIDE (T2O); TRITIUM WATER; WATER (T2O); OT2; OHS24509

CHEMICAL FAMILY:
Radioactive

Oxide

CREATION DATE: 02/27/91 REVISION DATE: 01/15/94

SECTION 2 COMPOSITION/INFORMATION ON INGREDIENTS

COMPONENT : TRITIATED WATER
CAS NUMBER: 14940-65-9
PERCENTAGE: 100.0

OTHER CONTAMINANTS: NONE

SECTION 3 HAZARDS IDENTIFICATION

CERCLA RATINGS (SCALE 0-3): HEALTH=U FIRE=0 REACTIVITY=0 PERSISTENCE=3
NFPA RATINGS (SCALE 0-4): HEALTH=U FIRE=0 REACTIVITY=0

EMERGENCY OVERVIEW:
Liquid.

May cause blood disorders. May cause convulsions. May affect the central nervous system. May cause adverse reproductive effects. May cause eye damage.

Avoid breathing vapor or mist. Avoid contact with eyes, skin and clothing. Keep container tightly closed. Wash thoroughly after handling. Use only with adequate ventilation. Handle with caution.

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EFFECTS: May cause lack of appetite, nausea, vomiting, diarrhea,

dehydration, weakness, drowsiness, incoordination, twitching, sterility, blood disorders, convulsions and shock.

LONG TERM EFFECTS: In addition to effects from short term exposure, anemia and cataracts may occur.

SKIN CONTACT:

SHORT TERM EFFECTS: May cause redness of the skin, blisters, sores and hair loss.

LONG TERM EFFECTS: In addition to effects from short term exposure, redness and swelling of the skin and rash may occur.

EYE CONTACT:

SHORT TERM EFFECTS: May cause redness and swelling of the eyes and eye damage.

LONG TERM EFFECTS: Same effects as short term exposure.

INGESTION:

SHORT TERM EFFECTS: No information available on significant adverse effects.

LONG TERM EFFECTS: No information available on significant adverse effects.

CARCINOGEN STATUS:
OSHA: N
NTP: N
IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION:

FIRST AID- Remove from exposure area to a restricted area with fresh air as quickly as possible. If breathing has stopped, perform artificial respiration by administering oxygen; mouth-to-mouth resuscitation should be avoided to prevent exposure to the person rendering first aid. Any evidence of serious contamination indicates that treatment must be instituted. (Inhalation of radioactive particles may indicate that other parts of the body were also contaminated, such as the digestive tract, skin and eyes.) If time permits, wipe the face with wet filter paper, force coughing and blowing of the nose. Get medical attention immediately. The victim may be contaminated with radioactive particles. Thorough decontamination should be started before the victim is moved to the medical area. Any personnel involved in rendering first aid must be monitored for radioactivity and throughly decontaminated if necessary (IAEA #3, pg.65).

SKIN CONTACT:

FIRST AID- Remove victim to a suitable area for decontamination as quickly as possible. Remove clothing and shoes immediately. Thoroughly wash the victim with soap and water, paying particular attention to the head, finger nails and palms of the hands. Upon completion of washing, monitor the victim for radioactivity. It is imperative that the skin should be decontaminated as quickly as possible. Minute skin injuries greatly increase the danger of isotope penetration into the victim; shaving should not be attempted. If water and soap have been inadequate in removing the radioactive compound, decontaminating compounds consisting of surfactants and absorbent substances may be effective. Complexing reagents may also be of use. The use of organic solvents is to be avoided, as they may increase the solubility and absorption of the radioactive substance. Skin contamination with radiation may be an indication that other parts of the body have been exposed. Contaminated clothing must be stored in a metal container for later decontamination or disposal. The water used to wash the victim must be stored in metal containers for later disposal. Any personnel involved in rendering first aid to the victim must be monitored for radioactivity and decontaminated if necessary (IAEA #47, pg.9; IAEA #3, pg.62).

EYE CONTACT:

FIRST AID- Remove victim to a restricted area for decontamination. Thoroughly wash eyes with large amounts of water, occasionally lifting the the upper and lower lids (approximately 15 minutes). Following the water treatment, provide an isotonic solution. Do not use eyebaths, rather provide a continuous and copious supply of fluid. Monitor the victim for radioactivity. If activity is present, rewash the eyes, and remonitor until little or no radioactivity is present. Get medical attention immediately. Any water used to wash the victims eyes must be stored in a metal container for later disposal. Any other articles that are used to decontaminate the victim must also be stored in metal containers for later decontamination or disposal. Any personnel involved in rendering first aid to the victim must be monitored for radioactivity and decontaminated if necessary (IAEA #3, pg.65; IAEA # 47, pg. 35).

INGESTION:

FIRST AID- In the case of ingestion of radioactive substances, the mouth should be rinsed out immediately after the accident, care being taken not to swallow the water used for this purpose. Vomiting should be induced either mechanically, or with syrup of ipecac. Do not induce vomiting in an unconscious person. Lavage may be useful. Care should be taken to avoid aspiration. The vomitus and lavage fluids should be saved for examination and monitoring. Further action depends on the nature of the radioactive substance. Get medical attention immediately. The gastric fluids and fluids used for lavage must be stored in metal containers for later disposal. The victim must be monitored for radioactivity and decontaminated, if necessary, before being transported to a medical facility. Any personnel involved in rendering first aid to the victim must be monitored for radioactivity and decontaminated if necessary (IAEA #47, pg.9; IAEA #3, pp. 59,66).

NOTE TO PHYSICIAN
ANTIDOTE:
TRITIUM POISONING:
No specific antidote recommended. Treatment by increasing liquid intake and by promoting diuresis has been indicated. It is possible to reduce the biological half-life from 10 days to 2.4 days simply by increasing the consumption of drinking water. The addition of diuretics may be indicated, but the risks and contraindictions of the therapy should be kept in mind. In the event of massive contamination, there might be a need for special treatment such as peritoneal dialysis or treatment with an artificial kidney. (IAEA Safety Series #47 Recommendations 1978). Treatment should be administered by qualified medical personnel.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD:
Negligible fire hazard when exposed to heat or flame.

EXTINGUISHING MEDIA:
Dry chemical, carbon dioxide, water spray or regular foam
(1990 Emergency Response Guidebook, DOT P 5800.5).

For larger fires, use water spray or fog (flooding amounts)
(1990 Emergency Response Guidebook, DOT P 5800.5).

FIREFIGHTING:
Do not move damaged containers; move undamaged containers out of fire zone. For massive fire in cargo area, use unmanned hose holder or monitor nozzles (1990 Emergency Response Guidebook, DOT P 5800.5, Guide Page 63).

Contact the local, state, or Department of Energy radiological response team. Extinguish using agents suitable for type of surrounding fire. Cool containers with flooding amounts of water, apply from as far a distance as possible. Avoid breathing dusts or vapors, keep upwind. Keep unnecessary people out of area until declared safe by radiological response team.

HAZARDOUS COMBUSTION PRODUCTS:
TRITIUM:
Emits low energy beta particles on decaying.

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL:
Do not touch damaged containers or spilled material. Damage to outer container may not affect primary inner container. For small liquid spills, take up with sand, earth or other absorbent material. For large spills, dike far ahead of spill for later disposal. Keep unnecessary people at least 150 feet upwind; greater distances may be necessary if advised by qualified radiation authority. Isolate hazard area and deny entry. Enter spill area only to save life; limit entry to shortest possible time. Detain uninjured persons and equipment exposed to radioactive material until arrival or instruction of qualified radiation authority. Delay cleanup until arrival or instruction of qualified radiation authority.

SECTION 7 HANDLING AND STORAGE

Observe all federal, state and local regulations when storing this substance.

Store in accordance with 10 CFR 20.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS:
Occupational exposure to radioactive substances must adhere to standards established by the Occupational Safety and Health Administration, 29 CFR 1910.96, and/or the Nuclear Regulatory Commission, 10 CFR part 20.

VENTILATION:
Provide local exhaust or process enclosure ventilation system.

One method of controlling external radiation exposure is to provide adequate shielding. The absorbing material used and the thickness required to attenuate the radiation to acceptable levels depends on the type of radiation, its energy, the flux and the dimensions of the source.
Alpha particles- for the energy range of alpha particles usually encountered, a fraction of a millimeter of any ordinary material is sufficient for absorbance. Thin rubber, acrylic, stout paper, or cardboard will suffice.
Beta particles- beta particles are more penetrating than alpha, and require more sheilding. Materials composed mostly of elements of low atomic number such as acrylic, aluminum and thick rubber are most appropriate for the absorption of beta particles. For example, 1/4 inch of acrylic will absorb all beta particles up to 1 MeV. With high energy beta radiation from large sources, Bremsstrahlung (X ray production) contribution may become significant and it may be necessary to provide additional sheilding of high atomic weight material, such as lead, to attenuate the Bremsstrahlung radiation.
Gamma rays- the most suitable materials for shielding gamma radiation are lead and iron. The thickness required will depend on whether the source is producing narrow or broad beam radiation. Primary and secondary protective barriers may be required to block all radiation.

EYE PROTECTION:
Employee must wear appropriate eye protection that will not allow the introduction of particles into the eyes. Contact lenses should not be worn.

Clothing, glove, and eye protection equipment will provide protection against alpha particles, and some protection against beta particles, depending on thickness, but will not shield gamma radiation.

CLOTHING:
Disposable overgarments, including head coverings and foot covering, should be worn by any employee engaged in handling any radiactive substance. These garments are also recommended even if the employee is working with a "glove box" containment system. Certain clothing fibers may be useful in dosimetry so clothing should be kept.
In the event of an accident, large scale release or a large scale clean-up full protective clothing will be necessary.

GLOVES:
Employee must wear appropriate protective gloves to prevent contact with this substance. Used gloves may present a radiation hazard and should be disposed of as radioactive waste.

RESPIRATOR:

These recommended respirators should provide protection for the respiratory tract against most of the radioactive particles encountered in the work place. These respirators will not offer protection against beta and gamma radiation, but may block alpha particles. From 10CFR20.103 Appendix A. Respiratory equipment must be certified by NIOSH/MSHA.

Type 'C' supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet or hood operated in continous-flow mode.

Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.

For firefighting and other immediately dangerous to life or health conditions:

Self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode.

Supplied-air respirator with full facepiece and operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION: Liquid.
MOLECULAR WEIGHT: 22.032
MOLECULAR FORMULA: T2-O
BOILING POINT: 216 F (102 C)
MELTING POINT: 32 F (0 C) (water)
SPECIFIC GRAVITY: 1.2138 g/L @ 25 C
WATER SOLUBILITY: not available
VAPOR PRESSURE: 760 mmHg @ 100 C (water)
TRITIUM HALF-LIFE: 12.26 years
TRITIUM DECAY ENERGY: 0.01861 MeV; SPECIFIC ACTIVITY: 9,700 Ci/g

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SECTION 10 STABILITY AND REACTIVITY

REACTIVITY:
Stable under normal temperatures and pressures.

CONDITIONS TO AVOID:
Radiation hazard, do not allow material to spread or contaminate water sources.

INCOMPATIBILITIES:
TRITIATED WATER:
No data available.

HAZARDOUS DECOMPOSITION:
TRITIUM:

Emits low energy beta particles on decaying.

POLYMERIZATION:
Hazardous polymerization has not been reported to occur under normal temperatures and pressures.

SECTION 11 TOXICOLOGY INFORMATION

TRITIATED WATER:
CARCINOGEN STATUS: None. However, exposure to ionizing radiation may cause cancer.
ACUTE TOXICITY LEVEL: No data available.
TARGET EFFECTS: Tritium, with a biological half-life of approximately 10 days, mixes with extracellular body water and therefore is distributed uniformly throughout the body.
ADDITIONAL DATA: Tritium emits beta particles. Exposure may result in whole body radiation.

HEALTH EFFECTS
INHALATION:
TRITIATED WATER:
See information on beta radiation.

BETA RADIATION:
ACUTE EXPOSURE- Beta emitters may or may not be absorbed, depending on the solubility and particle size. Insoluble compounds and heavier particles may remain at or near the site of deposition and be brought back up the throat via ciliary action. Soluble compounds may rapidly enter the bloodstream. Lighter particles may penetrate to the alveolar sacs and remain. The damage depends on how quickly they are eliminated, and the susceptibility of the tissue in which they are stored. A single large dose may lead to radiation sickness.
CHRONIC EXPOSURE- The effects of chronic exposure by internally deposited beta radiation is dependent upon the dose and target organ(s). If the total dose is sufficient, radiation sickness may occur. Possible disorders include lung cancer, sterility, anemia, leukemia or bone cancer.

RADIATION SICKNESS:
ACUTE EXPOSURE- Whole body doses of 200-1000 rads may cause anorexia, apathy, nausea and vomiting and may become maximal within 6-12 hours. An asymptomatic period of 24-36 hours may be followed by lymphopenia and slowly developing neutropenia. Thrombocytopenia may become prominent within 3-4 weeks. The lymph nodes, spleen and bone marrow may begin to atrophy. If bone marrow depression reaches a critical level, death may occur from overwhelming infection. Whole body doses of 400 or more rads may cause intractable nausea, vomiting and diarrhea that may lead to severe dehydration, vascular collapse and death. Regeneration of the intestinal epithelium may occur, but may be followed by hematopoietic failure within 2-3 weeks. Whole body doses of 600 or more rads may be fatal due to gastrointestinal or hematopoietic malfunction. With doses <600 rads, the possibility of survival is inversely related to the dose. Whole body doses >3000 rads generally cause nausea, vomitng, listlessness, drowsiness ranging from apathy to prostration, tremors, convulsions,

ataxia and death within a few hours. The gonads are also particularly radiosensitive. A single dose of 30 rads results in temporary sterility among men. In women, loss of fertility may be indicated by loss of menstruation.

CHRONIC EXPOSURE- The delayed effects of radiation may be due either to a single large overexposure or continuing low-level overexposure and may include cancer, genetic effects, shortening of life span and cataracts. Cancer is observed most frequently in the hematopoietic system, thyroid, bone and skin. Leukemia is among the most likely forms of malignancy. Lung cancer may also occur due to radioactive materials residing in the lungs. Genetic effects may range from point mutations to severe chromosome damage such as strand breakage, translocations, and deletions. If the germ cells have been affected, the effects of the mutation may not become apparent until the next generation, or even later.

SKIN CONTACT:
TRITIATED WATER:
See information on beta radiation.

BETA RADIATION:
ACUTE EXPOSURE- Contact may cause erythema, changes in pigmentation, epilation, blistering, necrosis, and ulceration. The skin is also subject to cancer formation after relatively severe skin damage. The effects may be worse at the site of a wound. Absorption or penetration through damaged skin may result in radiation sickness.

CHRONIC EXPOSURE- Small repeated doses may cause dermatitis. The hands may become dry and violet-red. Alopecia and urticaria may occur. The skin may become thin. In advanced cases, keratoses and warts may be formed, between which the skin may crack easily. Prolonged or repeated exposure may result in radiation sickness.

RADIATION SICKNESS:
The clinical course of radiation sickness depends upon the dose, dose rate, area of the body affected and time after exposure. External and internal radioactivity of any type may cause radiation sickness.
Radiation sickness has three (3) clearly defined syndromes which are described in detail in the inhalation section.

EYE CONTACT:
TRITIATED WATER:
See information on beta radiation.

BETA RADIATION:
ACUTE EXPOSURE- Exposure of the eye to beta emission may result in cornea and conjunctiva inflammation. The most sensitive part of the eye is the crystalline lens. A late effect of eye irradiation is cataract formation. It may begin anywhere from 6 months to several years after exposure. The cataracts begin at the posterior pole of the lens, and continue until the entire lens has been affected. Growth of the opacity may stop at any point. The rate of growth and the degree of opacity are dependent upon the dose of radiation.

CHRONIC EXPOSURE- Repeated or prolonged exposure to beta emission may cause cataracts, as discussed above. Of the well-documented late effects of radiation on man, leukemia and cataract formation have been observed at lower doses than those required to cause skin scarring, cancer, and bone tumors. The lens of the eye should be considered to be a critical organ.

RADIATION SICKNESS:

The eyes are very radiosensitive; a single dose of 100 rads may cause conjunctivitis and keratitis.
It is unlikely that a dose sufficient to cause radiation sickness would occur if only the eyes were irradiated. However, if eye damage by ionizing radiation occurs, it may be best to assume that other parts of the body have also been contaminated. Symptoms of radiation sickness are described in the inhalation section.

INGESTION:

TRITIATED WATER:

Generational studies indicate a reduction in litter size in progressive generations. See information on beta radiation.

BETA RADIATION:

ACUTE EXPOSURE- The fate of beta emitters depends on their physical and biological half-life. Ingestion may lead radiation sickness.
CHRONIC EXPOSURE- Repeated ingestion of beta emitters may lead to radiation sickness.

RADIATION SICKNESS:

The symptoms of radiation sickness depends upon the dose received. It may result from acute or chronic exposure to any form of radiation. The symptoms are described in the inhalation section.

SECTION 12 ECOLOGICAL INFORMATION

ENVIRONMENTAL IMPACT RATING (0-4): no data available

ACUTE AQUATIC TOXICITY: no data available

DEGRADABILITY: no data available

LOG BIOCONCENTRATION FACTOR (BCF): no data available

LOG OCTANOL/WATER PARTITION COEFFICIENT: no data available

SECTION 13 DISPOSAL INFORMATION

Observe all federal, state and local regulations when disposing of this substance.

Disposal must be in accordance with 10 CFR 20 and 60.

SECTION 14 TRANSPORTATION INFORMATION

U.S. DEPARTMENT OF TRANSPORTATION SHIPPING NAME-ID NUMBER, 49 CFR 172.101:
Radioactive material, n.o.s. (tritiated water)-UN 2982

U.S. DEPARTMENT OF TRANSPORTATION HAZARD CLASS OR DIVISION, 49 CFR 172.101:
7 - Radioactive material

U.S. DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS, 49 CFR 172.101 AND SUBPART E:
Radioactive

U.S. DEPARTMENT OF TRANSPORTATION PACKAGING AUTHORIZATIONS:
EXCEPTIONS: 49 CFR 173.421; 49 CFR 173.422 and 49 CFR 173.424
NON-BULK PACKAGING: 49 CFR 173.415 and 49 CFR 173.416
BULK PACKAGING: 49 CFR 173.415 and 49 CFR 173.416

SECTION 15 REGULATORY INFORMATION

TSCA STATUS: N

CERCLA SECTION 103 (40CFR302.4): N
SARA SECTION 302 (40CFR355.30): N
SARA SECTION 304 (40CFR355.40): N
SARA SECTION 313 (40CFR372.65): N
OSHA PROCESS SAFETY (29CFR1910.119): N
CALIFORNIA PROPOSITION 65: N

SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40 CFR 370.21)
ACUTE HAZARD: Y
CHRONIC HAZARD: Y
FIRE HAZARD: N
REACTIVITY HAZARD: N
SUDDEN RELEASE HAZARD: N

SECTION 16 OTHER

M S D S

Canadian Centre for Occupational Health and Safety

*** IDENTIFICATION ***

RECORD NUMBER : 709993
LANGUAGE : ENGLISH
PRODUCT NAME(S) : UNLEADED GASOLINE
PRODUCT IDENTIFICATION DATA : 0365V
DATE OF MSDS : 1993-12-08

*** MANUFACTURER INFORMATION ***

MANUFACTURER : Texaco Chile S A C
ADDRESS : Casilla 501 V
Correo 21
Santiago Chile
Telephone: 914-838-7204 (GENERAL MSDS ASSISTANCE) TECHNICAL INFORMATION: 914-838-7336 Fuels 512-459-6543 Chemicals 914-838-7509 Lubricants/Antifreezes
EMERGENCY TELEPHONE NO.(S) : 011-56-2-533-2177 (TRANSPORTATION EMERGENCY: Company)
800-424-9300 (TRANSPORTATION EMERGENCY: CHEMTREC)
914-831-3400 (HEALTH EMERGENCY: Company)

*** MATERIAL SAFETY DATA ***

PRODUCT CODE: 0365V Date Issued: 12/08/93 Supercedes: / /
PRODUCT NAME: UNLEADED GASOLINE

TEXACO
MATERIAL SAFETY DATA SHEET

NOTE: Read and understand Material Safety Data Sheet before handling or disposing of product.
N.D. - Not Determined N.A. - Not Applicable N.T. - Not Tested
< - Less Than > - Greater Than

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1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MATERIAL IDENTITY

Product Code and Name:
0365V UNLEADED GASOLINE

Chemical Name and/or Family or Description:
Automotive Lead-free Gasoline

Manufacturer's Name and Address:
Texaco Chile S.A.C.
Casilla 501 V Correo 21 Santiago, Chile

Telephone Numbers:

TRANSPORTATION EMERGENCY	Company:	56-2-533-2177
	CHEMTREC:	(800) 424-9300
HEALTH EMERGENCY	Company:	(914) 831-3400
GENERAL MSDS ASSISTANCE		(914) 838-7204
TECHNICAL INFORMATION	Fuels:	(914) 838-7336
	Chemicals:	(512) 459-6543
	Lubricants/Antifreezes:	(914) 838-7509

2. COMPOSITION/INFORMATION ON INGREDIENTS

THE CRITERIA FOR LISTING COMPONENTS IN THE COMPOSITION SECTION IS AS FOLLOWS: CHRONIC HAZARDS (CARCINOGENIC, TERATOGENIC, MUTAGENIC, NEUROTOXIC AND SENSITIZERS) ARE LISTED WHEN PRESENT AT 0.01% OR GREATER; ACUTE HAZARDS ARE LISTED WHEN PRESENT AT 1.0% OR GREATER AND NON-HAZARDOUS COMPONENTS ARE LISTED WHEN PRESENT AT 3.0% OR GREATER. THIS IS NOT INTENDED TO BE A COMPLETE COMPOSITIONAL DISCLOSURE.

Product and/or Component(s) Carcinogenic According to:

OSHA	IARC	NTP	OTHER	NONE
X	X	X	X	
-	-	-	-	-

Composition:

Chemical/Common Name	CAS No.	Range in %
* Gasoline consists mainly of straight chain and branched paraffinic hydrocarbons, olefins, cycloparaffins and aromatics. The benzene content normally varies from 0.2-3.5% with a typical value of 1.4%. The MTBE content varies from 0-15%.	MIXTURE	95.00 - 99.99

Chemical/Common Name	Exposure Limit
* Gasoline consists mainly of straight chain and branched paraffinic hydrocarbons, olefins, cycloparaffins and aromatics. The benzene content normally varies from 0.2-3.5% with a typical value of 1.4%. The MTBE content varies from 0-15%.	300ppm TWA OSHA 500ppm STEL OSHA 300 ppm TWA ACGIH 100 ppm TWA-TEXACO

Product is hazardous according to OSHA (1910.1200).

* Component(s) is hazardous according to OSHA or one or more state Right-to-Know laws.

3. HAZARD IDENTIFICATION

EMERGENCY OVERVIEW

Appearance and Odor:

Light straw to light red liquid

WARNING STATEMENT

DANGER] EXTREMELY FLAMMABLE LIQUID AND VAPOR
VAPOR MAY CAUSE FLASH FIRE
MAY CAUSE DIZZINESS AND DROWSINESS IF INHALED
MAY CAUSE IRRITATION TO EYES AND RESPIRATORY TRACT
ASPIRATION HAZARD IF SWALLOWED -
CAN ENTER LUNGS AND CAUSE DAMAGE

ATTENTION] POSSIBLE CANCER HAZARD - MAY CAUSE CANCER BASED ON

ANIMAL DATA

HMIS

Health:	1	**Reactivity:**	0
Flammability:	3	**Special:**	-

NFPA

Health:	1	**Reactivity:**	0
Flammability:	3	**Special:**	-

POTENTIAL HEALTH EFFECTS

	EYE	SKIN	INHALATION	INGESTION
Primary Route of Exposure:	X	X	X	
	-	-	-	-

Effects of Overexposure

Acute

Eyes:

May cause irritation, experienced as mild discomfort and seen as slight excess redness of the eye.

Skin:

Brief contact may cause slight irritation. Prolonged contact, as with clothing wetted with material, may cause more severe irritation and discomfort, seen as local redness and swelling.
No adverse effects expected from absorption of material through the skin.

Inhalation:

Vapors or mist may cause irritation of the nose and throat, headache, nausea, vomiting, dizziness, drowsiness, euphoria, loss of coordination, and disorientation. In poorly ventilated areas or confined spaces, unconsciousness and asphyxiation may result.

Ingestion:

If more than several mouthfuls are swallowed, abdominal discomfort, nausea, and diarrhea may occur. Aspiration may occur during swallowing or vomiting resulting in lung damage.

Sensitization Properties:

Unknown.

Chronic:

No adverse effects anticipated.

Medical Conditions Aggravated by Exposure:

Because of its irritating properties, repeated skin contact may aggravate an existing dermatitis (skin condition).

Other Remarks:

This product contains benzene. Prolonged and repeated exposure to benzene has been associated with anemia and leukemia in humans.

4. FIRST AID MEASURES

Eyes:

Immediately flush eyes with plenty of water for at least 15 minutes. Hold eyelids apart while flushing to rinse entire surface of eye and lids with water. Get medical attention.

Skin:

Wash skin with plenty of soap and water until all traces of material are removed. Remove and clean contaminated clothing (See Other Instructions). Destroy non-resistant footwear. Get medical attention if skin irritation persists or contact has been prolonged.

Ingestion:
If swallowed, get immediate medical attention. ONLY induce vomiting as directed by a doctor. Never give anything by mouth to an unconscious or convulsing person.

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, qualified personnel may administer oxygen. Get immediate medical attention.

Other Instructions:
NOTE TO PHYSICIAN: Aspiration of this product during induced emesis can result in lung injury. If evacuation of stomach contents is considered necessary, use method least likely to cause aspiration, such as gastric lavage after endotracheal intubation.

Remove and dry-clean or launder clothing soaked or soiled with this material before reuse. Dry cleaning of contaminated clothing may be more effective than normal laundering. Inform individuals responsible for cleaning of potential hazards associated with handling contaminated clothing.

5. FIRE-FIGHTING MEASURES

Ignition Temp. Degrees F.: 850 F
Flash Point Degrees F. (Method): -40F (COC)
Flammable Limits (%) Lower: 1.4% Upper: 7.6%

Recommended Fire Extinguishing Agents And Special Procedures:
According to NFPA Guide, use dry chemical, foam, or carbon dioxide. Water may be ineffective on flames, but should be used to cool fire-exposed containers. If a leak or spill has not ignited, use water spray to disperse the vapors and to provide protection for personnel attempting to stop the leak.
When handling, use non-sparking tools, ground and bond all containers.

Unusual or Explosive Hazards:
Gasoline vapors are heavier than air and may travel a considerable distance to a source of ignition and flash back. Flowing gasoline can generate static electricity and cause a fire explosion if a spark occurs in a flammable vapor-air atmosphere. When handling, use non-sparking tools, ground and bond all containers. Consult NFPA 77 for the proper handling precautions.

6. ACCIDENTAL RELEASE MEASURES

Transportation Spills Call: CHEMTREC (800) 424-9300

Procedures in Case of Accidental Release, Breakage or Leakage:
Eliminate all ignition sources including internal combustion engines and power tools. Ventilate area. Keep people away. Stay upwind and warn of possible downwind explosion hazard. Avoid breathing vapor. Wear self-contained breathing apparatus. Avoid contact with skin, eyes or clothing. Use self-contained breathing apparatus or supplied air mask for large

spills or confined areas. Contain spill if possible. Remove with inert absorbent. Prevent entry into sewers and waterways.

7. HANDLING AND STORAGE

Precautions to be Taken in Handling and Storage:

Transport, handle, and store in accordance with OSHA Regulation 1910.106 and applicable DOT Regulations. Ground and bond shipping container, transfer line, and receiving container. Use spark-proof tools. Keep away from heat, sparks, flame and other sources of ignition. Material may be at elevated temperatures and/or pressures. Exercise due care when opening bleeders and sampling ports.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Protective Equipment (Type)

Eye/Face Protection:

Chemical-type goggles or face shield recommended to prevent eye contact.

Skin Protection:

Gloves resistant to petroleum distillates are recommended to minimize skin contact. The most effective glove materials are Nitrile rubber, Teflon, or Viton for prolonged contact with gasoline. Protective clothing such as uniforms, coveralls, or boots should be also be worn where contact with product is likely. Launder or dry clean soiled clothes.

Respiratory Protection:

Airborne concentrations should be kept to lowest levels possible. If vapor, mist or dust is generated, use respirator approved by MSHA or NIOSH as appropriate. Supplied air respiratory protection should be used for cleaning large spills or upon entry into tanks, vessels, or other confined spaces. See below for applicable permissible concentrations.

Ventilation:

Use explosion-proof equipment to maintain adequate ventilation to meet occupational exposure limits, if applicable (see below), prevent accumulation of explosive air-gas mixtures, and avoid significant oxygen displacement. Oxygen levels should be at least 19.5% in confined spaces or other work areas (OSHA value).

Exposure Limit for Total Product:

OSHA PEL-TWA 300 ppm; STEL 500 ppm.
ACGIH TLV-TWA: 300 ppm; STEL 500 ppm.
TEXACO TLV-TWA: 100 ppm.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance and Odor:

Light straw to light red liquid

Boiling Point (Degrees F.):	>90
Specific Gravity:	0.7-.78 (H2O=1)
pH of undiluted product:	N.A.
Vapor Pressure:	465-775 @100'F mmhg
Viscosity:	<1.4 cSt @ 100F
Percent VOC:	100
Vapor Density:	3-4.0
Solubility in Water:	slight
Other:	N.D.

10. STABILITY AND REACTIVITY

This Material Reacts Violently With:
(If Others is checked below, see comments for details)

Air	Water	Heat	Strong Oxidizers	Others	None of These
		Y	Y		

Comments:
None

Products Evolved When Subjected to Heat or Combustion:
Toxic levels of carbon monoxide, carbon dioxide, irritating aldehydes and ketones.

	OCCUR	DO NOT OCCUR
Hazardous Polymerizations:		X

11. TOXICOLOGICAL INFORMATION

TOXICOLOGICAL INFORMATION(ANIMAL TOXICITY DATA)

Median Lethal Dose (LD50 LC50) (Species)

Oral:
believed to be > 5 g/kg (rat); practically non-toxic

Inhalation:
N.D.

Dermal:
believed to be > 3 g/kg (rabbit); practically non-toxic

Irritation Index, Estimation of Irritation (Species)

Skin:
believed to be >0.5-3/8.0 (rabbit); slightly irritating

Eyes:
believed to be <15/110 (rabbit); no appreciable effect

Sensitization:
N.D.

Other:

Studies in laboratory rats and mice exposed to constant levels of wholly vaporized unleaded gasoline for six hours per day, five days per week for two years caused kidney damage and kidney cancer in male rats and liver tumors in female mice. Many scientists do not believe that the male rat is an appropriate predictor of human kidney disease and are not in agreement on the relationship between liver tumors in laboratory animals and humans.
Prolonged and repeated exposure to benzene has caused anemia, lymphoma, and other cancers, in laboratory animals. Benzene has been shown to cause embryo/fetal toxicity and birth defects in laboratory animals, but only at doses which cause maternal toxicity (i.e., illness in the mother).
In male mice, prolonged and repeated exposure to high levels of MTBE vapor produced a higher than expected mortality due to urinary tract obstruction believed caused by physical non-neoplastic blockage of the urethral canal.
In female mice, data indicate increased incidence of hepatocellular adenomas (benign liver tumors).
Prolonged and repeated exposure to high levels of MTBE (up to 8000 ppm for over 15 months) resulted in excess mortality (82 %) in male rats.
Preliminary evaluation showed a chronic progressive nephrosis (kidney damage) as the possible cause of death.
Associated with the increased severity of nephropathy was an increase in

the number of renal tubular cell adenomas (benign kidney tumors) and carcinomas (malignant kidney tumors). There was also a difference in the number of testicular interstitial cell adenomas (benign testicular tumors).

MTBE has been shown to cause embryo/fetal toxicity and birth defects in mice, but only at maternally toxic doses. No developmental effects were seen in rabbits at the same exposure levels. Although the significance of these findings to humans is unclear, workers should minimize exposure to MTBE vapor.

Additional or repeat studies are planned or underway to better define the toxic potential of this product, or to verify the results obtained from previous animal studies.

12. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHODS

Dispose of this product in accordance with local and/or national regulations.

REMARKS

Do not allow to enter drains or sewers. Can cause explosion.

13. TRANSPORT INFORMATION

TRANSPORTATION

DOT:

PROPER SHIPPING NAME:
N.A.
HAZARD CLASS:
N.A.
IDENTIFICATION NUMBER: N.A.
LABEL REQUIRED:
N.A.

IMDG:

PROPER SHIPPING NAME:
N.A.
HAZARD CLASS:
N.A.
IDENTIFICATION NUMBER: N.A.
LABEL REQUIRED:
N.A.

IATA:

PROPER SHIPPING NAME:
N.A.
HAZARD CLASS:
N.A.
IDENTIFICATION NUMBER: N.A.
LABEL REQUIRED:
N.A.

TDG:

PROPER SHIPPING NAME:
N.A.
HAZARD CLASS:
N.A.
IDENTIFICATION NUMBER: N.A.

LABEL REQUIRED:
N.A.

14. REGULATORY INFORMATION

A. SARA TITLE III

Title III Section 302/304 Extremely Hazardous Substance:

Component	CAS No.	Percent	RQ (lbs)	TPQ (lbs)
N.A.				

CERCLA Section 102(a) Hazardous Substance

Component	CAS No.	Percent	RQ (lbs)
N.A.			

Title III Section 311 Hazard Categorization

Acute	Chronic	Fire	Pressure	Reactive	Not Applicable
					X
-	-	-	-	-	-

Title III Section 313 Toxic Chemicals

Component	CAS No.	Percent
N.A.		

B. WHMIS CLASSIFICATION
NA

C. MICHIGAN CRITICAL MATERIALS
N.A.

15. OTHER INFORMATION

THIS PRODUCT IS INTENDED FOR USE AS A MOTOR FUEL ONLY.

Texaco recommends that all exposures to this product be minimized by strictly adhering to recommended occupational controls procedures to avoid any potential adverse health effects.

Definitions of Terms :
OSHA - Occupational Safety and Health Administration (a regulatory and enforcement agency of safety and health in most United States industrial sectors; part of the United States Department of Labor.
PEL - Permissible Exposure Limit, OSHA workplace exposure limits for hazardous materials.
IARC - International Agency for Research on Cancer (part of the World Health Organization).
NTP - National Toxicology Program (overseen by the United States Department of Health and Human Services), develops tests for public health regulation of toxic chemicals.
ACGIH - American Conference of Governmental Industrial Hygienists, develops recommended exposure limits for chemical substances and physical agents.
TLV - Threshold Limit Value, ACGIH term for the airborne concentration of a material to which nearly all healthy workers can be exposed without adverse effects.
TLV-STEL: Short-term exposure limit, for brief exposure (15 minutes).
TLV-TWA : Time weighted Average concentration, for longer exposures(8 hrs).

HMIS - Hazardous Materials Identification System, developed by the National Paint and Coatings Association; numbers assigned to indicate the degree of hazard, with 0 for the least severe to 4 for the most severe.

NFPA - National Fire Protection Association (an international organization to promote fire prevention); a hazard ratings system similar to HMIS.

THE INFORMATION CONTAINED HEREIN IS BELIEVED TO BE ACCURATE. IT IS PROVIDED INDEPENDENTLY OF ANY SALE OF THE PRODUCT FOR PURPOSE OF HAZARD COMMUNICATION AS PART OF TEXACO'S PRODUCT SAFETY PROGRAM. IT IS NOT INTENDED TO CONSTITUTE PERFORMANCE INFORMATION CONCERNING THE PRODUCT. NO EXPRESS WARRANTY, OR IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE IS MADE WITH RESPECT TO THE PRODUCT OR THE INFORMATION CONTAINED HEREIN. DATA SHEETS ARE AVAILABLE FOR ALL TEXACO PRODUCTS. YOU ARE URGED TO OBTAIN DATA SHEETS FOR ALL TEXACO PRODUCTS YOU BUY, PROCESS, USE OR DISTRIBUTE AND YOU ARE ENCOURAGED AND REQUESTED TO ADVISE THOSE WHO MAY COME IN CONTACT WITH SUCH PRODUCTS OF THE INFORMATION CONTAINED HEREIN.

TO DETERMINE APPLICABILITY OR EFFECT OF ANY LAW OR REGULATION WITH RESPECT TO THE PRODUCT, USER SHOULD CONSULT HIS LEGAL ADVISOR OR THE APPROPRIATE GOVERNMENT AGENCY. TEXACO DOES NOT UNDERTAKE TO FURNISH ADVICE ON SUCH MATTERS.

Date: 12-08-93 X New Revised, Supersedes: - -

Date Printed: 03-09-94

Inquiries regarding MSDS should be directed to:

Texaco Inc.
Manager, Product Safety
P.O. Box 509
Beacon, N.Y. 12508

PLEASE SEE NEXT PAGE FOR PRODUCT LABEL

16. PRODUCT LABEL

READ AND UNDERSTAND MATERIAL SAFETY DATA SHEET
BEFORE HANDLING OR DISPOSING OF PRODUCT
0365V UNLEADED GASOLINE

WARNING STATEMENT

DANGER] EXTREMELY FLAMMABLE LIQUID AND VAPOR
VAPOR MAY CAUSE FLASH FIRE
MAY CAUSE DIZZINESS AND DROWSINESS IF INHALED
MAY CAUSE IRRITATION TO EYES AND RESPIRATORY TRACT
ASPIRATION HAZARD IF SWALLOWED -
CAN ENTER LUNGS AND CAUSE DAMAGE

ATTENTION] POSSIBLE CANCER HAZARD - MAY CAUSE CANCER BASED ON ANIMAL DATA

PRECAUTIONARY MEASURES

- Keep away from heat, sparks or flame.
- Use only with adequate ventilation.
- Avoid breathing vapor, mist or gas.
- Keep container closed.
- Never siphon by mouth.
- Wash throughly after handling.

FIRST AID

INGESTION:
If swallowed, get immediate medical attention. ONLY induce vomiting as directed by a doctor. Never give anything by mouth to an unconscious or convulsing person.

INHALATION:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, qualified personnel may administer oxygen. Get immediate medical attention.

EYE CONTACT:
Immediately flush eyes with plenty of water for at least 15 minutes. Hold eyelids apart while flushing to rinse entire surface of eye and lids with water. Get medical attention.

SKIN CONTACT:
Wash skin with plenty of soap and water until all traces of material are removed. Remove and clean contaminated clothing (See Other Instructions). Destroy non-resistant footwear. Get medical attention if skin irritation persists or contact has been prolonged.

NOTE TO PHYSICIAN:
Aspiration of this product during induced emesis can result in lung injury. If evacuation of stomach contents is considered necessary, use method least likely to cause aspiration, such as gastric lavage after endotracheal intubation.

FIRE

In case of fire, use foam, dry chemical, alcohol resistant foam or CO2. Water may be ineffective on flames. Use water spray to keep containers cool and protect personnel attempting to stop the leak.

Chemical/Common Name	CAS No.	Range in %
* Gasoline consists mainly of straight chain and branched paraffinic hydrocarbons, olefins, cycloparaffins and aromatics. The benzene content normally varies from 0.2-3.5% with a typical value of 1.4%. The MTBE content varies from 0-15%.	MIXTURE	95.00 - 99.99

Product is hazardous according to OSHA (1910.1200).

* Component(s) is hazardous according to OSHA or one or more state Right-to-Know laws.

HMIS
Health : 1 Reactivity : 0
Flammability: 3 Special : -
NFPA
Health : 1 Reactivity : 0
Flammability: 3 Special : -
DOT Proper Shipping Name: N.A.
DOT Hazardous Class : N.A.

CAUTION: Misuse of empty containers can be hazardous. Empty containers can be hazardous if used to store toxic, flammable, or reactive materials. Cutting or welding of empty containers might cause fire, explosion or toxic fumes from residues. Do not pressurize or expose to open flame or heat. Keep container closed and drum bungs in place.

Manufacturer's Name: Texaco Chile S.A.C.

TRANSPORTATION EMERGENCY

Company: 56-2-533-2177
CHEMTREC: (800) 424-9300

HEALTH EMERGENCY

Company: (914) 831-3400

PRODUCT #: 95690 NAME: XYLENE MIXTURE OF ISOMERS
MATERIAL SAFETY DATA SHEET, Valid 8/94 - 10/94
Printed Tuesday, August 16, 1994 10:53AM

Sigma Chemical Co.
P.O. Box 14508
St. Louis, MO 63178
Phone: 314-771-5765

Aldrich Chemical Co.
1001 West St. Paul
Milwaukee, WI 53233
Phone: 414-273-3850

Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779
Phone: 516-467-0980
Emergency Phone: 516-467-3535

SECTION 1. - - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - - -

PRODUCT #: 95690 NAME: XYLENE MIXTURE OF ISOMERS

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -

CAS #:1330-20-7
MF: C_8H_{10}

SYNONYMS

BENZENE, DIMETHYL- * DIMETHYLBENZENE * DIMETHYLBENZENE (OSHA) * KSYLEN (POLISH) * METHYL TOLUENE * NCI-C55232 * RCRA WASTE NUMBER U239 * UN1307 (DOT) * VIOLET 3 * XILOLI (ITALIAN) * XYLENE (ACGIH,DOT, OSHA) * XYLENEN (DUTCH) * XYLOL * XYLOLE (GERMAN) *

SECTION 3. - - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - - -

LABEL PRECAUTIONARY STATEMENTS

FLAMMABLE
HARMFUL
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
POSSIBLE RISK OF IRREVERSIBLE EFFECTS.
READILY ABSORBED THROUGH SKIN.
REPRODUCTIVE HAZARD.
TARGET ORGAN(S):
NERVES
LIVER, KIDNEYS
KEEP AWAY FROM SOURCES OF IGNITION. NO SMOKING.
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION.

SECTION 4. - - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.
WASH CONTAMINATED CLOTHING BEFORE REUSE.

SECTION 5. - - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - -

EXTINGUISHING MEDIA

CARBON DIOXIDE, DRY CHEMICAL POWDER OR APPROPRIATE FOAM.
WATER MAY BE EFFECTIVE FOR COOLING, BUT MAY NOT EFFECT EXTINGUISHMENT.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.
FLAMMABLE.
USE WATER SPRAY TO COOL FIRE-EXPOSED CONTAINERS.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

VAPOR MAY TRAVEL CONSIDERABLE DISTANCE TO SOURCE OF IGNITION AND FLASH BACK.

CONTAINER EXPLOSION MAY OCCUR UNDER FIRE CONDITIONS.

FORMS EXPLOSIVE MIXTURES IN AIR.

SECTION 6. - - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - - -

EVACUATE AREA.

SHUT OFF ALL SOURCES OF IGNITION.

WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.

COVER WITH AN ACTIVATED CARBON ADSORBENT, TAKE UP AND PLACE IN CLOSED CONTAINERS. TRANSPORT OUTDOORS.

VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - - -

REFER TO SECTION 8.

SECTION 8. - - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.

MECHANICAL EXHAUST REQUIRED.

SAFETY SHOWER AND EYE BATH.

USE NONSPARKING TOOLS.

DO NOT BREATHE VAPOR.

AVOID CONTACT WITH EYES, SKIN AND CLOTHING.

AVOID PROLONGED OR REPEATED EXPOSURE.

READILY ABSORBED THROUGH SKIN.

WASH THOROUGHLY AFTER HANDLING.

IRRITANT.

REPRODUCTIVE HAZARD.

KEEP TIGHTLY CLOSED.

KEEP AWAY FROM HEAT, SPARKS, AND OPEN FLAME.

STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - - -

APPEARANCE AND ODOR

COLORLESS LIQUID

BOILING POINT: 137 C TO 140 C

FLASHPOINT 85 F
29C

AUTOIGNITION TEMPERATURE: 867 F 463C

UPPER EXPLOSION LEVEL: 7%

LOWER EXPLOSION LEVEL: 1.1%

VAPOR PRESSURE: 18MM 37.7 C

VAPOR DENSITY: 3.7

SPECIFIC GRAVITY: 0.860

SECTION 10. - - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - - -

INCOMPATIBILITIES

OXIDIZING AGENTS

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS

TOXIC FUMES OF:
CARBON MONOXIDE, CARBON DIOXIDE

SECTION 11. - - - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - - -

ACUTE EFFECTS

HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.

VAPOR OR MIST IS IRRITATING TO THE EYES, MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.

EXPOSURE CAN CAUSE:
NARCOTIC EFFECT
LUNG IRRITATION, CHEST PAIN AND EDEMA WHICH MAY BE FATAL.
CNS DEPRESSION
DERMATITIS
GASTROINTESTINAL DISTURBANCES

CHRONIC EFFECTS
DAMAGE TO THE LIVER
DAMAGE TO THE KIDNEYS
BLOOD EFFECTS
OVEREXPOSURE MAY CAUSE REPRODUCTIVE DISORDER(S) BASED ON TESTS WITH LABORATORY ANIMALS.
TARGET ORGAN(S):
NERVES
LIVER, KIDNEYS

RTECS NO: ZE2100000
XYLENE

IRRITATION DATA

EYE-HMN 200 PPM	JIHTAB 25,282,43
SKN-RBT 100% MOD	AMIHAB 14,387,56
SKN-RBT 500 MG/24H MOD	28ZPAK -,24,72
EYE-RBT 87 MG MLD	AMIHAB 14,387,56
EYE-RBT 5 MG/24H SEV	28ZPAK -,24,72

TOXICITY DATA

ORL-HMN LDLO:50 MG/KG	YAKUD5 22,883,80
IHL-MAN LCLO:10000 PPM/6H	BMJOAE 3,442,70
ORL-RAT LD50:4300 MG/KG	AMIHAB 14,387,56
IHL-RAT LC50:5000 PPM/4H	NPIRI* 1,123,74
IPR-RAT LD50:2459 MG/KG	ENVRAL 40,411,86
SCU-RAT LD50:1700 MG/KG	NPIRI* 1,123,74
IPR-MUS LD50:1548 MG/KG	AGGHAR 18,109,60
ORL-MAM LD50:4300 MG/KG	GTPZAB 32(10),25,88
IHL-MAM LC50:30 GM/M3	GTPZAB 32(10),25,88

TARGET ORGAN DATA
PERIPHERAL NERVE AND SENSATION (FLACCID PARALYSIS WITHOUT ANESTHESIA)
SENSE ORGANS AND SPECIAL SENSES (OTHER OLFACTION EFFECTS)
SENSE ORGANS AND SPECIAL SENSES (CONJUNCTIVA IRRITATION)
BEHAVIORAL (CONVULSIONS OR EFFECT ON SEIZURE THRESHOLD)
BEHAVIORAL (IRRITABILITY)
LUNGS, THORAX OR RESPIRATION (OTHER CHANGES)
LIVER (FATTY LIVER DEGENERATION)
EFFECTS ON FERTILITY (POST-IMPLANTATION MORTALITY)
EFFECTS ON FERTILITY (ABORTION)
EFFECTS ON EMBRYO OR FETUS (FETOTOXICITY)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (CRANIOFACIAL)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (MUSCULOSKELETAL SYSTEM)
BIOCHEMICAL EFFECTS (OTHER TRANSFERASES)
ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - -

BURN IN A CHEMICAL INCINERATOR EQUIPPED WITH AN AFTERBURNER AND

SCRUBBER BUT EXERT EXTRA CARE IN IGNITING AS THIS MATERIAL IS HIGHLY FLAMMABLE.

OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - - -

CONTACT FLUKA CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - - -

REVIEWS, STANDARDS, AND REGULATIONS

ACGIH TLV-TWA 100 PPM; STEL 150 PPM 85INA8 6,1732,91
IARC CANCER REVIEW:ANIMAL INADEQUATE EVIDENCE IMEMDT 47,125,89
IARC CANCER REVIEW:HUMAN INADEQUATE EVIDENCE IMEMDT 47,125,89
IARC CANCER REVIEW:GROUP 3 IMEMDT 47,125,89
EPA FIFRA 1988 PESTICIDE SUBJECT TO REGISTRATION OR RE-REGISTRATION FEREAC 54,7740,89
OSHA PEL:8H TWA 100 PPM (435 MG/M3) FEREAC 54,2923,89
OSHA PEL FINAL:8H TWA 100 PPM (435 MG/M3);STEL 150 PPM (655 MG/M3) FEREAC 54,2923,89
OEL-ARAB REPUBLIC OF EGYPT:TWA 0.5 PPM (0.9 MG/M3) JAN93
OEL-AUSTRALIA:TWA 80 PPM (330 MG/M3);STEL 150 PPM (655 MG/M3) JAN93
OEL-BELGIUM:TWA 100 PPM (434 MG/M3);STEL 150 PPM (651 MG/M3) JAN93
OEL-CZECHOSLOVAKIA:TWA 200 MG/M3;STEL 1000 MG/M3 JAN93
OEL-DENMARK:TWA 50 PPM (217 MG/M3);SKIN JAN93
OEL-FINLAND:TWA 100 PPM (435 MG/M3);STEL 150 PPM;SKIN JAN93
OEL-FRANCE:TWA 100 PPM (435 MG/M3);STEL 150 PPM (650 MG/M3) JAN93
OEL-GERMANY:TWA 100 PPM (440 MG/M3) JAN93
OEL-HUNGARY:TWA 100 MG/M3;STEL 300 MG/M3 JAN93
OEL-JAPAN:TWA 100 PPM (430 MG/M3) JAN93
OEL-THE NETHERLANDS:TWA 100 PPM (435 MG/M3);SKIN JAN93
OEL-THE PHILIPPINES:TWA 0.1 MG/M3 JAN93
OEL-POLAND:TWA 100 MG/M3 JAN93
OEL-SWEDEN:TWA 50 PPM (200 MG/M3);STEL 100 PPM (450 MG/M3);SKIN JAN93
OEL-SWITZERLAND:TWA 100 PPM (436 MG/M3);STEL 200 PPM (870 MG/M3) JAN93
OEL-THAILAND:TWA 100 PPM (435 MG/M3) JAN93
OEL-TURKEY:TWA 100 PPM (435 MG/M3) JAN93
OEL-UNITED KINGDOM:TWA 100 PPM (435 MG/M3);STEL 150 PPM;SKIN JAN93
OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA CHECK ACGIH TLV
OEL IN NEW ZEALAND, SINGAPORE, VIETNAM CHECK ACGIH TLV
NIOSH REL TO XYLENE, ISOMERS-AIR:10H TWA 100 PPM;STEL 150 PPM NIOSH* DHHS #92-100,92
NOHS 1974: HZD 76720; NIS 367; TNF 99920; NOS 193; TNE 1016020
NOES 1983: HZD 76720; NIS 379; TNF 124029; NOS 221; TNE 1877151; TFE 364108
EPA GENETOX PROGRAM 1988, NEGATIVE: IN VITRO SCE-HUMAN LYMPHOCYTES; IN VITRO SCE-HUMAN
EPA TSCA CHEMICAL INVENTORY, JUNE 1993
EPA TSCA 8(A) PRELIMINARY ASSESSMENT INFORMATION, FINAL RULE FEREAC 47,26992,82
ON EPA IRIS DATABASE
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 1994
NTP CARCINOGENESIS STUDIES (GAVAGE);NO EVIDENCE:MOUSE, RAT NTPTR* NTP-TR-327,1986
NIOSH ANALYTICAL METHODS: SEE HYDROCARBONS, AROMATIC, 1501
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

SECTION 16. - - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - -

STOCK #:39595-1
MATERIAL SAFETY DATA SHEET, Valid 8/94 - 10/94
Printed Tuesday, August 16, 1994 10:51AM

Sigma Chemical Co.
P.O. Box 14508
St. Louis, MO 63178
Phone: 314-771-5765

Aldrich Chemical Co.
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Milwaukee, WI 53233
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Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779
Phone: 516-467-0980
Emergency Phone: 516-467-3535

SECTION 1. - - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - - -

STOCK #:39595-1
PRODUCT #: T1290 NAME: TETRACHLOROETHENE NEAT STANDARD FOR EPA METHODS

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -

CAS #:127-18-4
MF: C_2Cl_4

SYNONYMS

ANKILOSTIN * ANTISOL 1 * CARBON BICHLORIDE * CARBON DICHLORIDE * CZTEROCHLOROETYLEN (POLISH) * DIDAKENE * DILATIN PT * DOW-PER * ENT 1, 860 * ETHENE, TETRACHLORO- * ETHYLENE TETRACHLORIDE * FEDAL-UN * NCI-C04580 * NEMA * PER * PERAWIN * PERCHLOORETHYLEEN, PER (DUTCH) * PERCHLOR * PERCHLORAETHYLEN, PER (GERMAN) * PERCHLORETHYLENE * PERCHLOROETHYLENE * PERCHLOROETHYLENE (ACGIH,OSHA) * PERCLENE * PERCLENE D * PERCLOROETILENE (ITALIAN) * PERCOSOLVE * PERK * PERKLONE * PERSEC * RCRA WASTE NUMBER U210 * TETLEN * TETRACAP * TETRACHLOORETHEEN (DUTCH) * TETRACHLORAETHEN (GERMAN) * TETRACHLORETHYLENE * TETRACHLOROETHENE * TETRACHLOROETHYLENE * 1,1,2,2-TETRACHLOROETHYLENE * TETRACHLOROETHYLENE (DOT,OSHA) * TETRACLOROETENE (ITALIAN) * TETRALENO * TETRALEX * TETRAVEC * TETROGUER * TETROPIL * UN1897 (DOT) *

SECTION 3. - - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - -

LABEL PRECAUTIONARY STATEMENTS

TOXIC
MAY CAUSE CANCER.
MAY CAUSE HERITABLE GENETIC DAMAGE.
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
IRRITATING TO EYES, RESPIRATORY SYSTEM AND SKIN.
TARGET ORGAN(S):
LIVER
KIDNEYS
IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION.

SECTION 4. - - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
ASSURE ADEQUATE FLUSHING OF THE EYES BY SEPARATING THE EYELIDS WITH FINGERS.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS. CALL A PHYSICIAN.

REMOVE AND WASH CONTAMINATED CLOTHING PROMPTLY.

SECTION 5. - - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - -

EXTINGUISHING MEDIA

NONCOMBUSTIBLE.

USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

SECTION 6. - - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - -

EVACUATE AREA.

WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.

ABSORB ON SAND OR VERMICULITE AND PLACE IN CLOSED CONTAINERS FOR DISPOSAL.

VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - -

REFER TO SECTION 8.

SECTION 8. - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.

SAFETY SHOWER AND EYE BATH.

USE ONLY IN A CHEMICAL FUME HOOD.

DO NOT BREATHE VAPOR.

DO NOT GET IN EYES, ON SKIN, ON CLOTHING.

WASH THOROUGHLY AFTER HANDLING.

CARCINOGEN.

IRRITANT.

HARMFUL LIQUID AND FUMES.

MUTAGEN.

KEEP TIGHTLY CLOSED.

STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - -

DATA NOT AVAILABLE

BOILING POINT: 121 C

MELTING POINT: -22 C

SECTION 10. - - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - -

INCOMPATIBILITIES

STRONG BASES

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS

TOXIC FUMES OF:

PHOSGENE GAS

HYDROGEN CHLORIDE GAS

CARBON MONOXIDE, CARBON DIOXIDE

SECTION 11. - - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - -

ACUTE EFFECTS

HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.

VAPOR OR MIST IS IRRITATING TO THE EYES, MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT.

CAUSES SKIN IRRITATION.

EXPOSURE CAN CAUSE:

NAUSEA, DIZZINESS AND HEADACHE

NARCOTIC EFFECT

CHRONIC EFFECTS

DAMAGE TO THE LIVER
DAMAGE TO THE KIDNEYS
CARCINOGEN.
MAY ALTER GENETIC MATERIAL.
TARGET ORGAN(S):
NERVES, HEART
LIVER, KIDNEYS

RTECS NO: KX3850000

ETHYLENE, TETRACHLORO-

IRRITATION DATA

SKN-RBT 810 MG/24H SEV	EJTXAZ 9,171,76
SKN-RBT 500 MG/24H MLD	85JCAE -,108,86
EYE-RBT 162 MG MLD	EJTXAZ 9,171,76
EYE-RBT 500 MG/24H MLD	85JCAE -,108,86

TOXICITY DATA

ORL-RAT LD50:2629 MG/KG	AIHAAP 20,364,59
IHL-RAT LC50:34200 MG/M3/8H	AIHAAP 20,364,59
IPR-RAT LD50:4678 MG/KG	ENVRAL 40,411,86
ORL-MUS LD50:8100 MG/KG	NTIS** PB257-185
IHL-MUS LC50:5200 PPM/4H	APTOA6 9,303,53
SCU-MUS LD50:65 GM/KG	JPETAB 123,224,58
IPR-DOG LD50:2100 MG/KG	TXAPA9 10,119,67

TARGET ORGAN DATA

PERIPHERAL NERVE AND SENSATION (LOCAL ANESTHETIC)
SENSE ORGANS AND SPECIAL SENSES (CONJUNCTIVA IRRITATION)
BEHAVIORAL (GENERAL ANESTHETIC)
BEHAVIORAL (HALLUCINATIONS, DISTORTED PERCEPTIONS)
BEHAVIORAL (COMA)
LIVER (TUMORS)
KIDNEY, URETER, BLADDER (KIDNEY TUMORS)
BLOOD (LEUKEMIA)
PATERNAL EFFECTS (SPERMATOGENESIS)
EFFECTS ON FERTILITY (POST-IMPLANTATION MORTALITY)
EFFECTS ON EMBRYO OR FETUS (FETOTOXICITY)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (MUSCULOSKELETAL SYSTEM)
SPECIFIC DEVELOPMENTAL ABNORMALITIES (HOMEOSTASIS)
TUMORIGENIC EFFECTS (TESTICULAR TUMORS)
EFFECTS ON NEWBORN (LIVE BIRTH INDEX)
EFFECTS ON NEWBORN (BIOCHEMICAL AND METABOLIC)
EFFECTS ON NEWBORN (BEHAVIORAL)
TUMORIGENIC (CARCINOGENIC BY RTECS CRITERIA)
TUMORIGENIC (NEOPLASTIC BY RTECS CRITERIA)

ONLY SELECTED REGISTRY OF TOXIC EFFECTS OF CHEMICAL SUBSTANCES (RTECS) DATA IS PRESENTED HERE. SEE ACTUAL ENTRY IN RTECS FOR COMPLETE INFORMATION.

SECTION 12. - - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - - -

DISSOLVE OR MIX THE MATERIAL WITH A COMBUSTIBLE SOLVENT AND BURN IN A CHEMICAL INCINERATOR EQUIPPED WITH AN AFTERBURNER AND SCRUBBER. OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - - -

CONTACT SIGMA CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - -

REVIEWS, STANDARDS, AND REGULATIONS

ACGIH TLV-TWA 50 PPM; STEL 200 PPM 85INA8 6,1188,91
IARC CANCER REVIEW:ANIMAL SUFFICIENT EVIDENCE IMSUDL 7,355,87
IARC CANCER REVIEW:HUMAN INADEQUATE EVIDENCE IMSUDL 7,355,87
IARC CANCER REVIEW:GROUP 2B IMSUDL 7,355,87
EPA FIFRA 1988 PESTICIDE SUBJECT TO REGISTRATION OR RE-REGISTRATION
FEREAC 54,7740,89
MSHA STANDARD-AIR:TWA 100 PPM (670 MG/M3)
DTLVS* 3,201,71
OSHA PEL:8H TWA 100 PPM;CL 200;PK 300/5M/3H
FEREAC 54,2923,89
OSHA PEL FINAL:8H TWA 25 PPM (170 MG/M3)
FEREAC 54,2923,89
OEL-ARAB REPUBLIC OF EGYPT:TWA 5 PPM (35 MG/M3);SKIN JAN93
OEL-AUSTRALIA:TWA 50 PPM (335 MG/M3);STEL 150 PPM;CAR JAN93
OEL-BELGIUM:TWA 50 PPM (339 MG/M3);STEL 200 PPM (1368 MG/M3) JAN93
OEL-CZECHOSLOVAKIA:TWA 250 MG/M3;STEL 1250 MG/M3 JAN93
OEL-DENMARK:TWA 30 PPM (200 MG/M3);SKIN JAN93
OEL-FINLAND:TWA 50 PPM (335 MG/M3);STEL 75 PPM (520 MG/M3);SKIN JAN93
OEL-FRANCE:TWA 50 PPM (335 MG/M3) JAN93
OEL-GERMANY:TWA 50 PPM (345 MG/M3);CARCINOGEN JAN93
OEL-HUNGARY:STEL 50 MG/M3;SKIN;CARCINOGEN JAN93
OEL-JAPAN:TWA 50 PPM (340 MG/M3) JAN93
OEL-THE NETHERLANDS:TWA 35 PPM (240 MG/M3);SKIN JAN93
OEL-THE PHILIPPINES:TWA 100 PPM (670 MG/M3) JAN93
OEL-POLAND:TWA 60 MG/M3 JAN93
OEL-RUSSIA:TWA 50 PPM;STEL 10 MG/M3 JAN93
OEL-SWEDEN:TWA 10 PPM (70 MG/M3);STEL 25 PPM (170 MG/M3) JAN93
OEL-SWITZERLAND:TWA 50 PPM (345 MG/M3);STEL 100 PPM;SKIN JAN93
OEL-THAILAND:TWA 100 PPM;STEL 200 PPM JAN93
OEL-UNITED KINGDOM:TWA 50 PPM (335 MG/M3);STEL 150 PPM JAN93
OEL IN BULGARIA, COLOMBIA, JORDAN, KOREA CHECK ACGIH TLV
OEL IN NEW ZEALAND, SINGAPORE, VIETNAM CHECK ACGIH TLV
NIOSH REL TO TETRACHLOROETHYLENE-AIR:CA LOWEST FEASIBLE CONC.
NIOSH* DHHS #92-100,92
NOHS 1974: HZD 54790; NIS 288; TNF 52013; NOS 155; TNE 549154
NOES 1983: HZD 54790; NIS 242; TNF 42713; NOS 140; TNE 566270; TFE 141589
EPA GENETOX PROGRAM 1988, POSITIVE: CELL TRANSFORM.-RLV F344 RAT EMBRYO
EPA GENETOX PROGRAM 1988, POSITIVE: S CEREVISIAE GENE CONVERSION; S CEREVISIAE-HOMOZYGOSIS
EPA GENETOX PROGRAM 1988, POSITIVE: S CEREVISIAE-REVERSION
EPA GENETOX PROGRAM 1988, POSITIVE/LIMITED: CARCINOGENICITY-MOUSE/RAT
EPA GENETOX PROGRAM 1988, NEGATIVE: CELL TRANSFORM.-SA7/SHE
EPA TSCA CHEMICAL INVENTORY, JUNE 1993
EPA TSCA SECTION 8(E) STATUS REPORT
8EHQ-0979-0310;8EHQ-0680-0345;8EHQ-0578-0146
ON EPA IRIS DATABASE
EPA TSCA TEST SUBMISSION (TSCATS) DATA BASE, JANUARY 1994
NIOSH CURRENT INTELLIGENCE BULLETIN 20, 1978
NIOSH ANALYTICAL METHODS: SEE HYDROCARBONS, HALOGENATED, 1003
NCI CARCINOGENESIS BIOASSAY (GAVAGE);CLEAR EVIDENCE:MOUSE
NCITR* NCI-TR-13,77

NTP CARCINOGENESIS STUDIES (INHALATION);CLEAR EVIDENCE:MOUSE,RAT
NTPTR* NTP-TR-311,86
NCI CARCINOGENESIS BIOASSAY (GAVAGE);INADEQUATE STUDIES:RAT
NCITR* NCI-TR-13,77
NTP 7TH ANNUAL REPORT ON CARCINOGENS, 1992 : ANTICIPATED TO BE CARCINOGEN
THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

SECTION 16. - - - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - - -

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. SIGMA, ALDRICH, FLUKA SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

PRODUCT #: Z5422 NAME: TRICHLOROETHYLENE
MATERIAL SAFETY DATA SHEET, Valid 8/94 - 10/94
Printed Tuesday, August 16, 1994 10:52AM

Sigma Chemical Co.
P.O. Box 14508
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Aldrich Chemical Co.
1001 West St. Paul
Milwaukee, WI 53233
Phone: 414-273-3850

Fluka Chemical Corp.
980 South Second St.
Ronkonkoma, NY 11779
Phone: 516-467-0980
Emergency Phone: 516-467-3535

SECTION 1. - - - - - - - - - - CHEMICAL IDENTIFICATION- - - - - - - - - - -

PRODUCT #: Z5422 NAME: TRICHLOROETHYLENE

SECTION 2. - - - - - COMPOSITION/INFORMATION ON INGREDIENTS - - - - - -

DATA NOT AVAILABLE

SECTION 3. - - - - - - - - - - - HAZARDS IDENTIFICATION - - - - - - - - - -

LABEL PRECAUTIONARY STATEMENTS

TOXIC
MAY CAUSE CANCER.
MAY CAUSE HERITABLE GENETIC DAMAGE.
HARMFUL BY INHALATION, IN CONTACT WITH SKIN AND IF SWALLOWED.
CAUSES SEVERE IRRITATION.
TARGET ORGAN(S):
NERVES
LIVER, KIDNEYS
IN CASE OF ACCIDENT OR IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE IMMEDIATELY (SHOW THE LABEL WHERE POSSIBLE).
IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE.
WEAR SUITABLE PROTECTIVE CLOTHING, GLOVES AND EYE/FACE PROTECTION.

SECTION 4. - - - - - - - - - - - FIRST-AID MEASURES- - - - - - - - - - -

IN CASE OF CONTACT, IMMEDIATELY FLUSH EYES OR SKIN WITH COPIOUS AMOUNTS OF WATER FOR AT LEAST 15 MINUTES WHILE REMOVING CONTAMINATED CLOTHING AND SHOES.
IF INHALED, REMOVE TO FRESH AIR. IF NOT BREATHING GIVE ARTIFICIAL RESPIRATION. IF BREATHING IS DIFFICULT, GIVE OXYGEN.
IF SWALLOWED, WASH OUT MOUTH WITH WATER PROVIDED PERSON IS CONSCIOUS.
CALL A PHYSICIAN IMMEDIATELY.
DISCARD CONTAMINATED CLOTHING AND SHOES.

SECTION 5. - - - - - - - - - - FIRE FIGHTING MEASURES - - - - - - - - - -

EXTINGUISHING MEDIA

NONCOMBUSTIBLE.
USE EXTINGUISHING MEDIA APPROPRIATE TO SURROUNDING FIRE CONDITIONS.

SPECIAL FIREFIGHTING PROCEDURES

WEAR SELF-CONTAINED BREATHING APPARATUS AND PROTECTIVE CLOTHING TO PREVENT CONTACT WITH SKIN AND EYES.

UNUSUAL FIRE AND EXPLOSIONS HAZARDS

EMITS TOXIC FUMES UNDER FIRE CONDITIONS.

SECTION 6. - - - - - - - - - ACCIDENTAL RELEASE MEASURES- - - - - - - - -

EVACUATE AREA.
WEAR SELF-CONTAINED BREATHING APPARATUS, RUBBER BOOTS AND HEAVY RUBBER GLOVES.
ABSORB ON SAND OR VERMICULITE AND PLACE IN CLOSED CONTAINERS FOR DISPOSAL.
VENTILATE AREA AND WASH SPILL SITE AFTER MATERIAL PICKUP IS COMPLETE.

SECTION 7. - - - - - - - - - - - HANDLING AND STORAGE- - - - - - - - - - -

REFER TO SECTION 8.

SECTION 8. - - - - - - - EXPOSURE CONTROLS/PERSONAL PROTECTION- - - - - -

WEAR APPROPRIATE NIOSH/MSHA-APPROVED RESPIRATOR, CHEMICAL-RESISTANT GLOVES, SAFETY GOGGLES, OTHER PROTECTIVE CLOTHING.
SAFETY SHOWER AND EYE BATH.
USE ONLY IN A CHEMICAL FUME HOOD.
DO NOT BREATHE VAPOR.
DO NOT GET IN EYES, ON SKIN, ON CLOTHING.
AVOID PROLONGED OR REPEATED EXPOSURE.
WASH THOROUGHLY AFTER HANDLING.
SEVERE IRRITANT.
HARMFUL VAPOR.
CARCINOGEN.
MUTAGEN.
KEEP TIGHTLY CLOSED.
PROTECT FROM LIGHT.
STORE IN A COOL DRY PLACE.

SECTION 9. - - - - - - - - PHYSICAL AND CHEMICAL PROPERTIES - - - - - - - -

APPEARANCE AND ODOR
COLORLESS LIQUID
BOILING POINT: 86.7 C TO 87 C
MELTING POINT: -84.8 C
FLASHPOINT NONE
AUTOIGNITION TEMPERATURE: 770 F 409C
UPPER EXPLOSION LEVEL: 90% 57 C
LOWER EXPLOSION LEVEL: 12.5% 57 C
VAPOR PRESSURE: 61MM 20 C
VAPOR DENSITY: 4.5
SPECIFIC GRAVITY: 1.463

SECTION 10. - - - - - - - - - -STABILITY AND REACTIVITY - - - - - - - - - -

INCOMPATIBILITIES
OXIDIZING AGENTS
REDUCING AGENTS
STRONG BASES
ALUMINUM
MAGNESIUM
SENSITIVE TO LIGHT

HAZARDOUS COMBUSTION OR DECOMPOSITION PRODUCTS
TOXIC FUMES OF:
CARBON MONOXIDE, CARBON DIOXIDE
HYDROGEN CHLORIDE GAS
PHOSGENE GAS

SECTION 11. - - - - - - - - - - - TOXICOLOGICAL INFORMATION - - - - - - - - -

ACUTE EFFECTS
HARMFUL IF SWALLOWED, INHALED, OR ABSORBED THROUGH SKIN.
CAUSES SEVERE IRRITATION.
HIGH CONCENTRATIONS ARE EXTREMELY DESTRUCTIVE TO TISSUES OF THE MUCOUS MEMBRANES AND UPPER RESPIRATORY TRACT, EYES AND SKIN.
SYMPTOMS OF EXPOSURE MAY INCLUDE BURNING SENSATION, COUGHING, WHEEZING, LARYNGITIS, SHORTNESS OF BREATH, HEADACHE, NAUSEA AND VOMITING.
EXPOSURE TO AND/OR CONSUMPTION OF ALCOHOL MAY INCREASE TOXIC EFFECTS.
EXPOSURE CAN CAUSE:
GASTROINTESTINAL DISTURBANCES

DAMAGE TO THE KIDNEYS
NAUSEA, DIZZINESS AND HEADACHE
NARCOTIC EFFECT
PROLONGED CONTACT CAN CAUSE:
DERMATITIS

CHRONIC EFFECTS
CARCINOGEN.
MAY ALTER GENETIC MATERIAL.
TARGET ORGAN(S):
CENTRAL NERVOUS SYSTEM
LIVER, KIDNEYS
HEART
LUNGS

SECTION 12. - - - - - - - - - - - ECOLOGICAL INFORMATION - - - - - - - - - - -

DATA NOT YET AVAILABLE.

SECTION 13. - - - - - - - - - - - DISPOSAL CONSIDERATIONS - - - - - - - - - -

DISSOLVE OR MIX THE MATERIAL WITH A COMBUSTIBLE SOLVENT AND BURN IN A CHEMICAL INCINERATOR EQUIPPED WITH AN AFTERBURNER AND SCRUBBER.
OBSERVE ALL FEDERAL, STATE AND LOCAL ENVIRONMENTAL REGULATIONS.

SECTION 14. - - - - - - - - - - - - TRANSPORT INFORMATION - - - - - - - - - -

CONTACT SIGMA CHEMICAL COMPANY FOR TRANSPORTATION INFORMATION.

SECTION 15. - - - - - - - - - - - REGULATORY INFORMATION - - - - - - - - - - -

THIS PRODUCT IS SUBJECT TO SARA SECTION 313 REPORTING REQUIREMENTS.

SECTION 16. - - - - - - - - - - - - OTHER INFORMATION- - - - - - - - - - - - -

THE ABOVE INFORMATION IS BELIEVED TO BE CORRECT BUT DOES NOT PURPORT TO BE ALL INCLUSIVE AND SHALL BE USED ONLY AS A GUIDE. SIGMA, ALDRICH, FLUKA SHALL NOT BE HELD LIABLE FOR ANY DAMAGE RESULTING FROM HANDLING OR FROM CONTACT WITH THE ABOVE PRODUCT. SEE REVERSE SIDE OF INVOICE OR PACKING SLIP FOR ADDITIONAL TERMS AND CONDITIONS OF SALE.

Appendix C

Trench and Excavation Safety

(2) Unless employees can step safely to or from the wharf, float, barge, or river towboat, either a ramp, meeting the requirements of subparagraph (1) of this paragraph, or a safe walkway, shall be provided.

(3) Jacob's ladders shall be of the double rung or flat tread type. They shall be well maintained and properly secured.

(4) A Jacob's ladder shall either hang without slack from its lashings or be pulled up entirely.

(5) When the upper end of the means of access rests on or is flush with the top of the bulwark, substantial steps properly secured and equipped with at least one substantial hand rail approximately 33 inches in height, shall be provided between the top of the bulwark and the deck.

(6) Obstructions shall not be laid on or across the gangway.

(7) The means of access shall be adequately illuminated for its full length.

(8) Unless the structure makes it impossible, the means of access shall be so located that the load will not pass over employees.

(c) *Working surfaces of barges.* (1) Employees shall not be permitted to walk along the sides of covered lighters or barges with coamings more than 5 feet high, unless there is a 3-foot clear walkway, or a grab rail, or a taut handline is provided.

(2) Decks and other working surfaces shall be maintained in a safe condition.

(3) Employees shall not be permitted to pass fore and aft, over, or around deckloads, unless there is a safe passage.

(4) Employees shall not be permitted to walk over deckloads from rail to coaming unless there is a safe passage. If it is necessary to stand at the outboard or inboard edge of the deckload where less than 24 inches of bulwark, rail, coaming, or other protection exists, all employees shall be provided with a suitable means of protection against falling from the deckload.

(d) *First-aid and lifesaving equipment.* (1) Provisions for rendering first aid and medical assistance shall be in accordance with Subpart D of this part.

(2) The employer shall ensure that there is in the vicinity of each barge in use at least one U.S. Coast Guard-approved 30-inch lifering with not less than 90 feet of line attached, and at least one portable or permanent ladder which will reach the top of the apron to the surface of the water. If the above equipment is not available at the pier, the employer shall furnish it during the time that he is working the barge.

(3) Employees walking or working on the unguarded decks of barges shall be protected with U.S. Coast Guard-approved work vests or buoyant vests.

(e) *Commercial diving operations.* Commercial diving operations shall be subject to Subpart T of Part 1910, § §1910.401-1910.441 , of this chapter.

[39 FR 22801, June 24, 1974, as amended at 42 FR 37674, July 22, 1977]

§1926.606 Definitions applicable to this subpart.

(a) "Apron" —The area along the waterfront edge of the pier or wharf.

(b) "Bulwark"—The side of a ship above the upper deck.

(c) "Coaming"—The raised frame, as around a hatchway in the deck,. to keep out water.

(d) "Jacob's ladder"—A marine ladder of rope or chain with wooden or metal rungs.

(e) "Rail", for the purpose of § 1926.605 , means a light structure serving as a guard at the outer edge of a ship's deck.

Subpart P—Excavations

Authority note: Sec. 107, Contract Work Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, and 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), 9-83 (48 FR 35736), or 1-90 (55 FR 9033,) as applicable.

Section 1926.651 is also issued under 29 CFR part 1911

[Subpart P authority citation amended by 59 FR 40729, August 9, 1994]

§1926.650 Scope, application, and definitions applicable to this subpart.

(a) *Scope and application.* This subpart applies to all open excavations made in the earth's surface. Excavations are defined to include trenches.

(b) *Definitions applicable to this subpart.*

Accepted engineering practices means those requirements which are compatible with standards of practice required by a registered professional engineer.

Aluminum Hydraulic Shoring means a pre-engineered shoring system comprised of aluminum hydraulic cylinders (crossbraces) used in conjunction with vertical rails (uprights) or horizontal rails (walers). Such system is designed, specifically to support the sidewalls of an excavation and prevent cave-ins.

Bell-bottom pier hole means a type of shaft or footing excavation, the bottom of which is made larger than the cross section above to form a belled shape.

Benching (Benching system) means a method of protecting employees from cave-ins by excavating the sides of an excavation to form one or a series of horizontal levels or steps, usually with vertical or near-vertical surfaces between levels.

Cave-in means the separation of a mass of soil or rock material from the side of an excavation, or the loss of soil from under a trench shield or support system, and its sudden movement into the excavation, either by falling or sliding, in sufficient quantity so that it could entrap, bury, or otherwise injure and immobilize a person.

Competent person means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

Cross braces mean the horizontal members of a shoring system installed perpendicular to the sides of the excavation, the ends of which bear against either uprights or wales.

Excavation means any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

Faces or *sides* means the vertical or inclined earth surfaces formed as a result of excavation work.

Failure means the breakage, displacement, or permanent deformation of a structural member or connection so as to reduce its structural integrity and its supportive capabilities.

Hazardous atmosphere means an atmosphere which by reason of being explosive, flammable, poisonous, corrosive, oxidizing, irritating, oxygen deficient, toxic, or otherwise harmful, may cause death, illness, or injury.

Kickout means the accidental release or failure of a cross brace.

Protective system means a method of protecting employees from cave-ins, from material that could fall or roll from an excavation face or into an excavation, or from the collapse of adjacent structures. Protective systems include support systems, sloping and benching systems, shield systems, and other systems that provide the necessary protection.

Ramp means an inclined walking or working surface that is used to gain access to one point from another, and is constructed from earth or from structural materials such as steel or wood.

Registered Professional Engineer means a person who is registered as a professional engineer in the state where the work is to be performed. However, a professional engineer, registered in any state is deemed to be a "registered professional engineer" within the meaning of this standard when approving designs for "manufactured protective systems" or "tabulated data" to be used in interstate commerce.

Sheeting means the members of a shoring system that retain the earth in position and in turn are supported by other members of the shoring system.

Shield (Shield system) means a structure that is able to withstand the forces imposed on it by a cave-in and thereby protect employees within the structure. Shields can be permanent structures or can be designed to be portable and moved along as work progresses. Additionally, shields can be either premanufactured or job-built in accordance with §1926.652 (c)(3) or (c)(4) . Shields used in trenches are usually referred to as "trench boxes" or "trench shields."

Shoring (Shoring system) means a structure such as a metal hydraulic, mechanical or timber shoring system that supports the sides of an excavation and which is designed to prevent cave-ins.

Sides. See "Faces."

Sloping (Sloping system) means a method of protecting employees from cave-ins by excavating to form sides of an excavation that are inclined away from the excavation so as to prevent cave-ins. The angle of incline required to prevent a cave-in varies with differences in such factors as the soil type, environmental conditions of exposure, and application of surcharge loads.

Stable rock means natural solid mineral material that can be excavated with vertical sides and will remain intact while exposed. Unstable rock is considered to be stable when the rock material on the side or sides of the excavation is secured against caving-in or movement by rock bolts or by another protective system that has been designed by a registered professional engineer.

Structural ramp means a ramp built of steel or wood, usually used for vehicle access. Ramps made of soil or rock are not considered structural ramps.

Support system means a structure such as underpinning, bracing, or shoring, which provides support to an adjacent structure, underground installation, or the sides of an excavation.

Tabulated data means tables and charts approved by a registered professional engineer and used to design and construct a protective system.

Trench (Trench excavation) means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

Trench box. See "Shield."

Trench shield. See "Shield."

Uprights means the vertical members of a trench shoring system placed in contact with the earth and usually positioned so that individual members do not contact each other. Uprights placed so that individual members are closely spaced, in contact with or interconnected to each other, are often called "sheeting."

Wales means horizontal members of a shoring system placed parallel to the excavation face whose sides bear against the vertical members of the shoring system or earth.

§1926.651 Specific excavation requirements.

[1926.651 head revised by 59 FR 40729, August 9, 1994]

(a) *Surface encumbrances.* All surface encumbrances that are located so as to create a hazard to employees shall be removed or supported, as necessary, to safeguard employees.

(b) *Underground installations.* (1) The estimated location of utility installations, such as sewer, telephone, fuel, electric, water lines, or any other underground installations that reasonably may be expected to be encountered during excavation work, shall be determined prior to opening an excavation.

(2) Utility companies or owners shall be contacted within established or customary local response times, advised of the proposed work, and asked to establish the location of the utility underground installations prior to the start of actual excavation. When utility companies or owners cannot respond to a request to locate underground utility installations within 24 hours (unless a longer period is required by state or local law), or cannot establish the exact location of these installations, the employer may proceed, provided the employer does so with caution, and provided detection equipment or other acceptable means to locate utility installations are used.

(3) When excavation operations approach the estimated location of underground installations the exact location of the installations shall be determined by safe and acceptable means.

(4) While the excavation is open, underground installations shall be protected, supported or removed as necessary to safeguard employees.

(c) *Access and egress*— (1) *Structural ramps.* (i) Structural ramps that are used solely by employees as a means of access or egress from excavations shall be designed by a competent person. Structural ramps used for access or egress of equipment shall be designed by a competent person qualified in structural design, and shall be constructed in accordance with the design.

(ii) Ramps and runways constructed of two or more structural members shall have the structural members connected together to prevent displacement.

(iii) Structural members used for ramps and runways shall be of uniform thickness.

(iv) Cleats or other appropriate means used to connect runway structural members shall be attached to the bottom of the runway or shall be attached in a manner to prevent tripping.

(v) Structural ramps used in lieu of steps shall be provided with cleats or other surface treatments on the top surface to prevent slipping.

(2) *Means of egress from trench excavations* . A stairway, ladder, ramp or other safe means of egress shall be located in trench excavations that are 4 feet (1.22 m) or more in depth so as to require no more than 25 feet (7.62 m) of lateral travel for employees.

(d) *Exposure to vehicular traffic* . Employees exposed to public vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.

(e) *Exposure to falling loads* . No employee shall be permitted underneath loads handled by lifting or digging equipment. Employees shall be required to stand away from any vehicle being loaded or unloaded to avoid being struck by any spillage or falling materials. Operators may remain in the cabs of vehicles being loaded or unloaded when the vehicles are equipped, in accordance with § 1926.601(b)(6) , to provide adequate protection for the operator during loading and unloading operations.

(f) *Warning system for mobile equipment* . When mobile equipment is operated adjacent to an excavation, or when such equipment is required to approach the edge of an excavation, and the operator does not have a clear and direct view of the edge of the excavation, a warning system shall be utilized such as barricades, hand or mechanical signals, or stop logs. If possible, the grade should be away from the excavation.

(g) *Hazardous atmospheres*— (1) *Testing and controls* . In addition to the requirements set forth in subparts D and E of this part (29 CFR 1926.50 -1926.107) to prevent exposure to harmful levels of atmospheric contaminants and to assure acceptable atmospheric conditions, the following requirements shall apply:

(i) Where oxygen deficiency (atmospheres containing less than 19.5 percent oxygen) or a hazardous atmosphere exists or could reasonably be expected to exist, such as in excavations in landfill areas or excavations in areas where hazardous substances are stored nearby, the atmospheres in the excavation shall be tested before employees enter excavations greater than 4 feet (1.22 m) in depth.

(ii) Adequate precautions shall be taken to prevent employee exposure to atmospheres containing less than 19.5 percent oxygen and other hazardous atmospheres. These precautions include providing proper respiratory protection or ventilation in accordance with subparts D and E of this part respectively.

(iii) Adequate precaution shall be taken such as providing ventilation, to prevent employee exposure to an atmosphere containing a concentration of a flammable gas in excess of 20 percent of the lower flammable limit of the gas.

(iv) When controls are used that are intended to reduce the level of atmospheric contaminants to acceptable levels, testing shall be conducted as often as necessary to ensure that the atmosphere remains safe.

(2) *Emergency rescue equipment.* (i) Emergency rescue equipment, such as breathing apparatus, a safety harness and line, or a basket stretcher, shall be readily available where hazardous atmospheric conditions exist or may reasonably be expected to develop during work in an excavation. This equipment shall be attended when in use.

(ii) Employees entering bell-bottom pier holes, or other similar deep and confined footing excavations, shall wear a harness with a life-line securely attached to it. The lifeline shall be separate from any line used to handle materials, and shall be individually attended at all times while the employee wearing the lifeline is in the excavation.

(h) *Protection from hazards associated with water accumulation.* (1) Employees shall not work in excavations in which there is accumulated water, or in excavations in which water is accumulating, unless adequate precautions have been taken to protect employees against the hazards posed by water accumulation. The precautions necessary to protect employees adequately vary with each situation, but could include special support or shield systems to protect from cave-ins, water removal to control the level of accumulating water, or use of a safety harness and lifeline.

(2) If water is controlled or prevented from accumulating by the use of water removal equipment, the water removal equipment and operations shall be monitored by a competent person to ensure proper operation.

(3) If excavation work interrupts the natural drainage of surface water (such as streams), diversion ditches, dikes, or other suitable means shall be used to prevent surface water from entering the excavation and to provide adequate drainage of the area adjacent to the excavation. Excavations subject to to runoff from heavy rains will require an inspection by a competent person and compliance with paragraphs (h)(1) and (h)(2) of this section.

(i) *Stability of adjacent structures.* (1) Where the stability of adjoining buildings, walls, or other structures is endangered by excavation operations support systems such as shoring, bracing, or underpinning shall be provided to ensure the stability of such structures for the protection of employees.

(2) Excavation below the level of the base or footing of any foundation or retaining wall that could be reasonably expected to pose a hazard to employees shall not be permitted except when:

(i) A support system, such as underpinning, is provided to ensure the safety of employees and the stability of the structure; or

(ii) The excavation is in stable rock; or

(iii) A registered professional engineer has approved the determination that the structure is sufficiently removed from the excavation so as to be unaffected by the excavation activity; or

(iv) A registered professional engineer has approved the determination that such excavation work will not pose a hazard to employees.

(3) Sidewalks, pavements, and appurtenant structure shall not be undermined unless a support system or another method of protection is provided to protect employees from the possible collapse of such structures.

(j) *Protection of employees from loose rock or soil.* (1) Adequate protection shall be provided to protect employees from loose rock or soil that could pose a hazard by falling or rolling from an excavation face. Such protection shall consist of scaling to remove loose material; installation of protective barricades at intervals as necessary on the face to stop and contain falling material; or other means that provide equivalent protection.

(2) Employees shall be protected from excavated or other materials or equipment that could pose a hazard by falling or rolling into excavations. Protection shall be provided by placing and keeping such materials or equipment at least 2 feet (.61 m) from the edge of excavations, or by the use of retaining devices that are sufficient to prevent materials or equipment from falling or rolling into excavations, or by a combination of both if necessary.

(k) *Inspections.* (1) Daily inspections of excavations, the adjacent areas, and protective systems shall be made by a competent person for evidence of a situation that could result in possible cave-ins, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions. An inspection shall be conducted by the competent person prior to the start of work and as needed throughout the shift. Inspections shall also be made after every rainstorm or other hazard increasing occurrence. These inspections are only required when employee exposure can be reasonably anticipated.

(2) Where the competent person finds evidence of a situation that could result in a possible cave-in, indications of failure of protective systems, hazardous atmospheres, or other hazardous conditions, exposed employees shall be removed from the hazardous area until the necessary precautions have been taken to ensure their safety.

(l) Walkways shall be provided where employees or equipment are required or permitted to cross over excavations. Guardrails which comply with §1926.502(b) shall be provided where walkways are 6 feet (1.8 m) or more above lower levels.

[1926.651(l) revised by 59 FR 40729, August 9, 1994]

§1926.652 Requirements for protective systems.

(a) *Protection of employees in excavations.* (1) Each employee in an excavation shall be protected from cave-ins by an adequate protective system designed in accordance with paragraph (b) or (c) of this section except when:

(i) Excavations are made entirely in stable rock; or

(ii) Excavations are less than 5 feet (1.52 m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.

(2) Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

(b) *Design of sloping and benching systems* . The slopes and configurations of sloping and benching systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (b)(1); or, in the alternative, paragraph (b)(2); or, in the alternative, paragraph (b)(3), or, in the alternative, paragraph (b)(4), as follows:

(1) *Option (1)— Allowable configurations and slopes.* (i) Excavations shall be sloped at an angle not steeper than one and one-half horizontal to one vertical (34 degrees measured from the horizontal), unless the employer uses one of the other options listed below.

(ii) Slopes specified in paragraph (b)(1)(i) of this section, shall be excavated to form configurations that are in accordance with the slopes shown for Type C soil in Appendix B to this subpart.

(2) *Option (2)—Determination of slopes and configurations using Appendices A and B* . Maximum allowable slopes, and allowable configurations for sloping and benching systems, shall be deter-

mined in accordance with the conditions and requirements set forth in appendices A and B to this subpart.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of sloping or benching systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and shall include all of the following:

(A) Identification of the parameters that affect the selection of a sloping or benching system drawn from such data;

(B) Identification of the limits of use of the data, to include the magnitude and and configuration of slopes determined to be safe;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)— Design by a registered professional engineer.* (i) Sloping and benching systems not utilizing Option (1) or Option (2) or Option (3) under paragraph (b) of this section shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include at least the following;

(A) The magnitude of the slopes that were determined to be safe for the particular project;

(B) The configurations that were determined to be safe for the particular project; and

(C) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite while the slope is being constructed. After that time the design need not be at the jobsite, but a copy shall be made available to the Secretary upon request.

(c) *Design of support systems, shield systems, and other protective systems.* Designs of support systems, shield systems, and other protective systems shall be selected and constructed by the employer or his designee and shall be in accordance with the requirements of paragraph (c)(1); or, in the alternative, paragraph (c)(2); or, in the alternative, paragraph (c)(3); or, in the alternative, paragraph (c)(4) as follows:

[Sec. 1926.652(c)]

(1) *Option (1)—Designs using appendices A, C, and D.* Designs for timber shorting in trenches shall be determined in accordance with the conditions and requirements set forth in appendices A and C to this subpart. Designs for aluminum hydraulic shoring shall be in accordance with paragraph (c)(2) of this section, but if manufacturer's tabulated data cannot be utilized, designs shall be in accordance with appendix D.

(2) *Option (2)—Designs Using Manufacturer's Tabulated Data.* (i) Design of support systems, shield systems, or other protective systems that are drawn from manufacturer's tabulated data shall be in accordance with all specifications, recommendations, and limitations issued or made by the manufacturer.

(ii) Deviation from the specifications, recommendations, and limitations issued or made by the manufacturer shall only be allowed after the manufacturer issues specific written approval.

(ii) Manufacturer's specifications, recommendations, and limitations, and manufacturer's approval to deviate from the specifications, recommendations, and limitations shall be in written form at the jobsite during construction of the protective system. After that time this data may be stored off the jobsite, but a copy shall be made available to the Secretary upon request.

(3) *Option (3)—Designs using other tabulated data.* (i) Designs of support systems, shield systems, or other protective systems shall be selected from and be in accordance with tabulated data, such as tables and charts.

(ii) The tabulated data shall be in written form and include all of the following:

(A) Identification of the parameters that affect the selection of a protective system drawn from such data;

(B) Identification of the limits of use of the data;

(C) Explanatory information as may be necessary to aid the user in making a correct selection of a protective system from the data.

(iii) At least one copy of the tabulated data, which identifies the registered professional engineer who approved the data, shall be maintained at the jobsite during construction of the protective system. After that time the data may be stored off the jobsite, but a copy of the data shall be made available to the Secretary upon request.

(4) *Option (4)—Design by a registered professional engineer.* (i) Support systems, shield systems, and other protective systems not utilizing Option 1, Option 2 or Option 3, above, shall be approved by a registered professional engineer.

(ii) Designs shall be in written form and shall include the following:

(A) A plan indicating the sizes, types, and configurations of the materials to be used in the protective system; and

(B) The identity of the registered professional engineer approving the design.

(iii) At least one copy of the design shall be maintained at the jobsite during construction of the protective system. After that time, the design may be stored off the jobsite, but a copy of the design shall be made available to the Secretary upon request.

(d) *Materials and equipment.* (1) Materials and equipment used for protective systems shall be free from damage or defects that might impair their proper function.

(2) Manufactured materials and equipment used for protective systems shall be used and maintained in a manner that is consistent with the recommendations of the manufacturer, and in a manner that will prevent employee exposure to hazards.

(3) When material or equipment that is used for protective systems is damaged, a competent person shall examine the material or equipment and evaluate its suitability for continued use. If the competent person cannot assure the material or equipment is able to support the intended loads or is otherwise suitable for safe use, then such material or equipment shall be removed from service, and shall be evaluated and approved by a registered professional engineer before being returned to service.

(e) *Installation and removal of support*—(1) *General.* (i) Members of support systems shall be securely connected together to prevent sliding, falling, kickouts, or other predictable failure.

(ii) Support systems shall be installed and removed in a manner that protects employees from cave-ins, structural collapses, or from being struck by members of the support system.

(iii) Individual members of support systems shall not be subjected to loads exceeding those which those members were designed to withstand.

(iv) Before temporary removal of individual members begins, additional precautions shall be taken to ensure the safety of employees, such as installing other structural members to carry the loads imposed on the support system.

(v) Removal shall begin at, and progress from, the bottom of the excavation. Members shall be released slowly so as to note any indication of possible failure of the remaining members of the structure or possible cave-in of the sides of the excavation.

(vi) Backfilling shall progress together with the removal of support systems from excavations.

(2) *Additional requirements for support systems for trench excavations.* (i) Excavation of material to a level no greater than 2 feet (.61 m) below the bottom of the members of a support system shall be permitted, but only if the system is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the support system.

(ii) Installation of a support system shall be closely coordinated with the excavation of trenches.

(f) *Sloping and benching systems.* Employees shall not be permitted to work on the faces of sloped or benched excavations at levels above other employees except when employees at the lower levels are adequately protected from the hazard of falling, rolling, or sliding material or equipment.

(g) *Shield systems*—(1) *General.* (i) Shield systems shall not be subjected to loads exceeding those which the system was designed to withstand.

(ii) Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

(iii) Employees shall be protected from the hazard of cave-ins when entering or exiting the areas protected by shields.

(iv) Employees shall not be allowed in shields when shields are being installed, removed, or moved vertically.

(2) *Additional requirement for shield systems used in trench excavations.* Excavations of earth material to a level not greater than 2 feet (.61 m) below the bottom of a shield shall be permitted, but only if the shield is designed to resist the forces calculated for the full depth of the trench, and there are no indications while the trench is open of a possible loss of soil from behind or below the bottom of the shield.

Appendix A to Subpart P

Soil Classification

(a) *Scope and application*—(1) *Scope.* This appendix describes a method of classifying soil and rock deposits based on site and environmental conditions, and on the structure and composition of the earth deposits. The appendix contains definitions, sets forth requirements, and describes acceptable visual and manual tests for use in classifying soils.

(2) *Application.* This appendix applies when a sloping or benching system is designed in accordance with the requirements set forth in §1926.652(b)(2) as a method of protection for employees from cave-ins. This appendix also applies when timber shoring for excavations is designed as a method of protection from cave-ins in accordance with appendix C to subpart P of part 1926, and when aluminum hydraulic shoring is designed in accordance with appendix D. This Appendix also applies if other protective systems are designed and selected for use from data prepared in accordance with the requirements set forth in §1926.652(c), and the use of the data is predicated on the use of the soil classification system set forth in this appendix.

(b) *Definitions.* The definitions and examples given below are based on, in whole or in part, the following: American Society for Testing Materials (ASTM) Standards D653-85 and D2488; The Unified Soils Classification System, The U.S. Department of Agriculture (USDA) Textural Classification

Scheme; and The National Bureau of Standards Report BSS-121.

Cemented soil means a soil in which the particles are held together by a chemical agent, such as calcium carbonate, such that a hand-sized sample cannot be crushed into powder or individual soil particles by finger pressure.

Cohesive soil means clay (fine grained soil), or soil with a high clay content, which has cohesive strength. Cohesive soil does not crumble, can be excavated with vertical sideslopes, and is plastic when moist. Cohesive soil is hard to break up when dry, and exhibits significant cohesion when submerged. Cohesive soils include clayey silt, sandy clay, silty clay, clay and organic clay.

Dry soil means soil that does not exhibit visible signs of moisture content.

Fissured means a soil material that has a tendency to break along definite planes of fracture with little resistance, or a material that exhibits open cracks, such as tension cracks, in an exposed surface.

Granular soil means gravel, sand, or silt, (coarse grained soil) with little or no clay content. Granular soil has no cohesive strength. Some moist granular soils exhibit apparent cohesion. Granular soil cannot be molded when moist and crumbles easily when dry.

Layered system means two or more distinctly different soil or rock types arranged in layers. Micaceous seams or weakened planes in rock or shale are considered layered.

Moist soil means a condition in which a soil looks and feels damp. Moist cohesive soil can easily be shaped into a ball and rolled into small diameter threads before crumbling. Moist granular soil that contains some cohesive material will exhibit signs of cohesion between particles.

Plastic means a property of a soil which allows the soil to be deformed or molded without cracking, or appreciable volume change.

Saturated soil means a soil in which the voids are filled with water. Saturation does not require flow. Saturation, or near saturation, is necessary for the proper use of instruments such as a pocket penetrometer or sheer vane.

Soil classification system means, for the purpose of this subpart, a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability. The categories are determined based on an analysis of the properties and performance characteristics of the deposits and the environmental conditions of exposure.

Stable rock means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

Submerged soil means soil which is underwater or is free seeping.

Type A means cohesive soils with an unconfined compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:

(i) The soil is fissured; or

(ii) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or

(iii) The soil has been previously disturbed; or

(iv) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H: 1V) or greater; or

(v) The material is subject to other factors that would require it to be classified as a less stable material.

Type B means:

(i) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or

(ii) Granular cohesionless soils including: angular gravel (similar to crushed rock), silt silt loam, sandy loam and, in some cases silty clay loam and sandy clay loam.

(iii) Previously disturbed soils except those which would otherwise be classed as Type C soil.

(iv) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or

(v) Dry rock that is not stable; or

(vi) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.

Type C means:

(i) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or

(ii) Granular soils including gravel, sand, and loamy sand, or

(iii) Submerged soil or soil from which water is freely seeping; or

(iv) Submerged rock that is not stable, or

(v) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.

Unconfined compressive strength means the load per unit area at which a soil will fail in compression. It can be determined by laboratory testing, or estimated in the field using a pocket penetrometer, by thumb penetration tests, and other methods.

Wet soil means soil that contains significantly more moisture than moist soil, but in such a range of values that cohesive material will slump or begin to flow when vibrated. Granular material that would exhibit cohesive properties when moist will lose those cohesive properties when wet.

(c) *Requirements*—(1) *Classification of soil and rock deposits.* Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in paragraph (b) of this appendix.

(2) *Basis of classification.* The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses shall be conducted by a competent person using tests described in paragraph (d) below, or in other recognized methods of soil classification and testing such as those adopted by the America Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.

(3) *Visual and manual analyses.* The visual and manual analyses, such as those noted as being acceptable in paragraph (d) of this appendix, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.

(4) *Layered systems.* In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.

(5) *Reclassification.* If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

(d) *Acceptable visual and manual tests*—(1) *Visual tests.* Visual analysis is conducted to determine qualitative information regarding the excavation site in general, the soil adjacent to the excavation, the soil forming the sides of the open excavation, and the soil taken as samples from excavated material.

(i) Observe samples of soil that are excavated and soil in the sides of the excavation. Estimate the range of particle sizes and the relative amounts of the particle sizes. Soil that is primarily composed of fine-grained material is cohesive material. Soil composed primarily of coarse-grained sand or gravel is granular material.

(ii) Observe soil as it is excavated. Soil that remains in clumps when excavated is cohesive. Soil that breaks up easily and does not stay in clumps is granular.

(iii) Observe the side of the open excavation and the surface area adjacent to the excavation. Crack-like openings such as tension cracks could indicate fissured material. If chunks of soil spall off a vertical side, the soil could be fissured. Small spalls are evidence of moving ground and are indications of potentially hazardous situations.

(iv) Observe the area adjacent to the excavation and the excavation itself for evidence of existing utility and other underground structures, and to identify previously disturbed soil.

(v) Observe the opened side of the excavation to identify layered systems. Examine layered systems to identify if the layers slope toward the excavation. Estimate the degree of slope of the layers.

(vi) Observe the area adjacent to the excavation and the sides of the opened excavation for evidence of surface water, water seeping from the sides of the excavation, or the location of the level of the water table.

(vii) Observe the area adjacent to the excavation and the area within the excavation for sources of vibration that may affect the stability of the excavation face.

(2) *Manual tests.* Manual analysis of soil samples is conducted to determine quantitative as well as qualitative properties of soil and to provide more information in order to classify soil properly.

(i) *Plasticity.* Mold a moist or wet sample of soil into a ball and attempt to roll it into threads as thin as 1/2-inch in diameter. Cohesive material can be successfully rolled into threads without crumbling. For example, if at least a two inch (50 mm) length of 1/2-inch thread can be held on one end without tearing, the soil is cohesive.

(ii) *Dry strength*. If the soil is dry and crumbles on its own or with moderate pressure into individual grains or fine powder, it is granular (any combination of gravel, sand, or silt). If the soil is dry and falls into clumps which break up into smaller clumps, but the smaller clumps can only be broken up with difficulty, it may be clay in any combination with gravel, sand or silt. If the dry soil breaks into clumps which do not break up into small clumps and which can only be broken with difficulty, and there is no visual indication the soil is fissured, the soil may be considered unfissured.

(iii) *Thumb penetration*. The thumb penetration test can be used to estimate the unconfined compressive strength of cohesive soils. (This test is based on the thumb penetration test described in American Society for Testing and Materials (ASTM) Standard designation D2488 —"Standard Recommended Practice for Description of Soils (Visual—Manual Procedure).") Type A soils with an unconfined compressive strength of 1.5 tsf can be readily indented by the thumb; however, they can be penetrated by the thumb only with very great effort. Type C soils with an unconfined compressive strength of 0.5 tsf can be easily penetrated several inches by the thumb, and can be molded by light finger pressure. This test should be conducted on an undisturbed soil sample, such as a large clump of spoil, as soon as practicable after excavation to keep to a minimum the effects of exposure to drying influences. If the excavation is later exposed to wetting influences (rain, flooding), the classification of the soil must be changed accordingly.

(iv) *Other strength tests*. Estimates of unconfined compressive strength of soils can also be obtained by use of a pocket penetrometer or by using a hand-operated shearvane.

(v) *Drying test*. The basic purpose of the drying test is to differentiate between cohesive material with fissures, unfissured cohesive material, and granular material. The procedure for the drying test involves drying a sample of soil that is approximately one inch thick (2.54 cm) and six inches (15.24 cm) in diameter until it is thoroughly dry:

(A) If the sample develops cracks as it dries, significant fissures are indicated.

(B) Samples that dry without cracking are to be broken by hand. If considerable force is necessary to break a sample, the soil has significant cohesive material content. The soil can be classified as an unfissured cohesive material and the unconfined compressive strength should be determined.

(C) If a sample breaks easily by hand, it is either a fissured cohesive material or a granular material. To distinguish between the two, pulverize the dried clumps of the sample by hand or by stepping on them. If the clumps do not pulverize easily, the material is cohesive with fissures. If they pulverize easily into very small fragments, the material is granular.

Appendix B to Subpart P

Sloping and Benching

(a) *Scope and application*. This appendix contains specifications for sloping and benching when used as methods of protecting employees working in excavations from cave-ins. The requirements of this appendix apply when the design of sloping and benching protective systems is to be performed in accordance with the requirements set forth in §1926.652(b)(2).

(b) *Definitions*.

Actual slope means the slope to which an excavation face is excavated.

Distress means that the soil is in a condition where a cave-in is imminent or is likely to occur. Distress is evidenced by such phenomena as the development of fissures in the face of or adjacent to an open excavation; the subsidence of the edge of an excavation; the slumping of material from the face or the bulging or heaving of material from the bottom of an excavation; the spalling of material from the face of an excavation; and ravelling, i.e., small amounts of material such as pebbles or little clumps of material suddenly separating from the face of an excavation and trickling or rolling down into the excavation.

Maximum allowable slope means the steepest incline of an excavation face that is acceptable for the most favorable site conditions as protection against cave-ins, and is expressed as the ratio of horizontal distance to vertical rise (H:V).

Short term exposure means a period of time less than or equal to 24 hours that an excavation is open.

(c) *Requirements*—(1) *Soil classification*. Soil and rock deposits shall be classified in accordance with appendix A to subpart P of part 1926.

(2) *Maximum allowable slope*. The maximum allowable slope for a soil or rock deposit shall be determined from Table B-1 of this appendix.

Table B-1

Maximum Allowable Slopes

SOIL OR ROCK TYPE	MAXIMUM ALLOWABLE SLOPES (H:V) [1] FOR EXCAVATIONS LESS THAN 20 FEET DEEP [3]	
STABLE ROCK	VERTICAL	(90°)
TYPE A [2]	¾:1	(53°)
TYPE B	1:1	(45°)
TYPE C	1½:1	(34°)

NOTES:

1. Numbers shown in parentheses next to maximum allowable slopes are angles expressed in degrees from the horizontal. Angles have been rounded off.
2. A short-term maximum allowable slope of 1/2H:1V (63°) is allowed in excavations in Type A soil that are 12 feet (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 feet (3.67 m) in depth shall be 3/4H:1V (53°).
3. Sloping or benching for excavations greater than 20 feet deep shall be designed by a registered professional engineer.

(3) *Actual slope.* (i) The actual slope shall not be steeper than the maximum allowable slope.

(ii) The actual slope shall be less steep than the maximum allowable slope, when there are signs of distress. If that situation occurs, the slope shall be cut back to an actual slope which is at least ½ horizontal to one vertical (½H:1V) less steep than the maximum allowable slope.

(iii) When surcharge loads from stored material or equipment, operating equipment, or traffic are present, a competent person shall determine the degree to which the actual slope must be reduced below the maximum allowable slope, and shall assure that such reduction is achieved. Surcharge loads from adjacent structures shall be evaluated in accordance with §1926.651(i).

(4) *Configurations.* Configurations of sloping and benching systems shall be in accordance with Figure B-1.

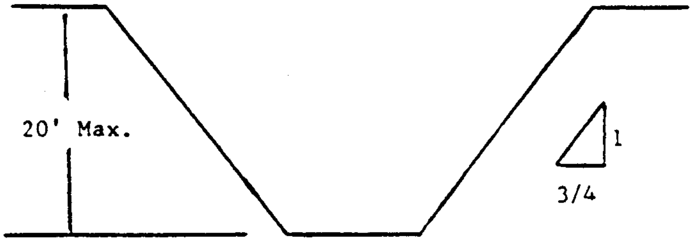
Figure B-1

Slope Configurations

(All slopes stated below are in the horizontal to vertical ratio)

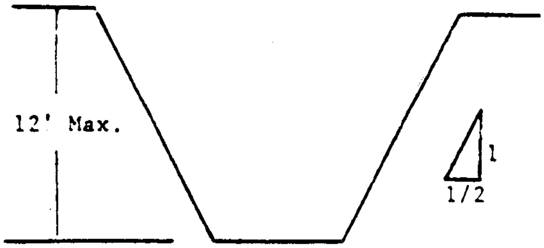
B-1.1 Excavations made in Type A soil.

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of ¾:1.



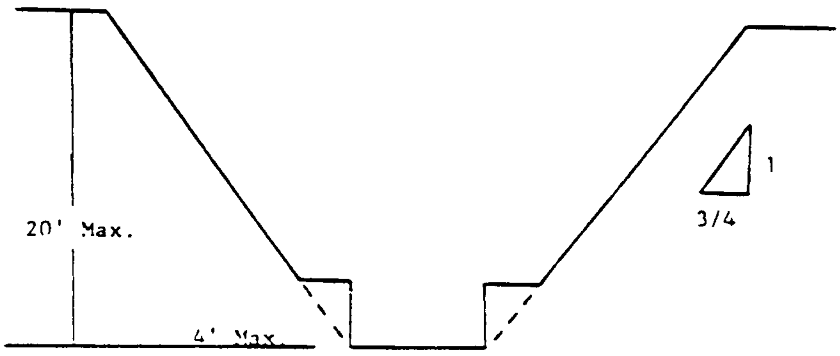
Simple Slope—General

Exception: Simple slope excavations which are open 24 hours or less (short term) and which are 12 feet or less in depth shall have a maximum allowable slope of ½:1.

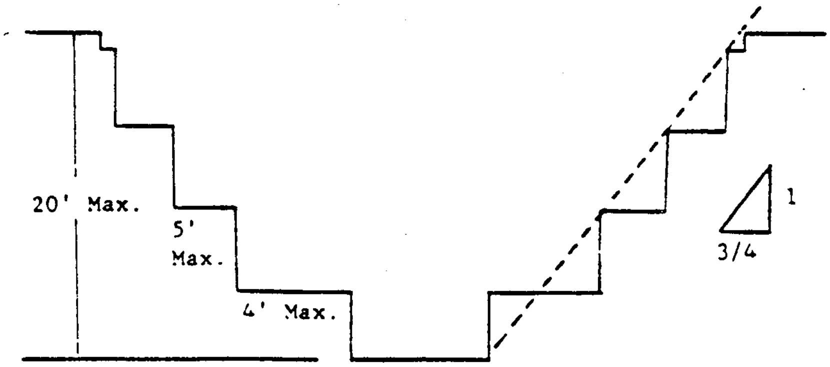


Simple Slope—Short Term

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of ¾ to 1 and maximum bench dimensions as follows:

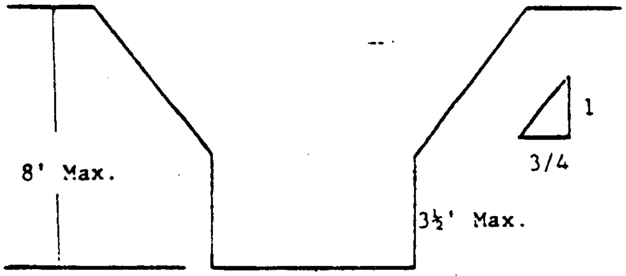


Simple Bench



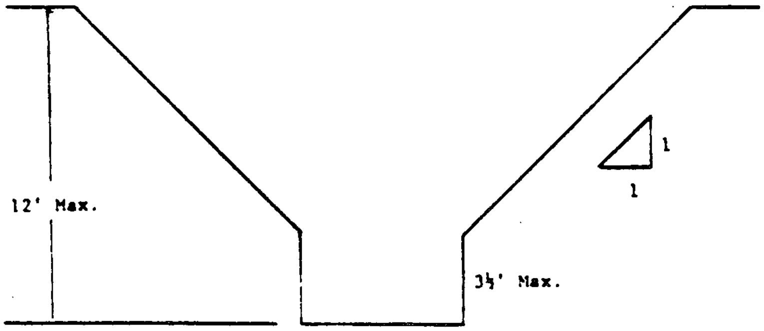
Multiple Bench

3. All excavations 8 feet or less in depth which have unsupported vertically sided lower portions shall have a maximum vertical side of 3½ feet.



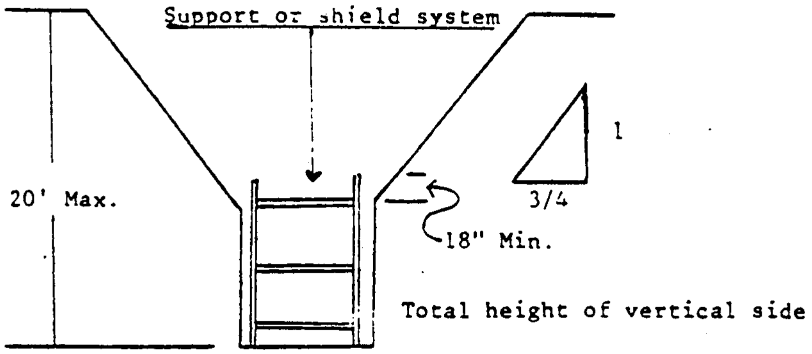
Unsupported Vertically Sided Lower Portion—Maximum 8 Feet in Depth

All excavations more than 8 feet but not more than 12 feet in depth which unsupported vertically sided lower portions shall have a maximum allowable slope of 1:1 and a maximum vertical side of 3½ feet.



Unsupported Vertically Sided Lower Portion—Maximum 12 Feet in Depth

All excavations 20 feet or less in depth which have vertically sided lower portions that are supported or shielded shall have a maximum allowable slope of ³⁄₄:1. The support or shield system must extend at least 18 inches above the top of the vertical side.

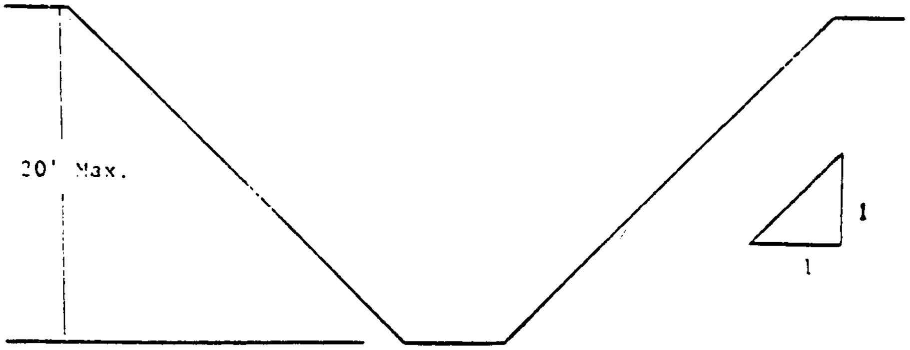


Supported or Shielded Vertically Sided Lower Portion

4. All other simple slope, compound slope, and vertically sided lower portion excavations shall be in accordance with the other options permitted under §1926.652(b).

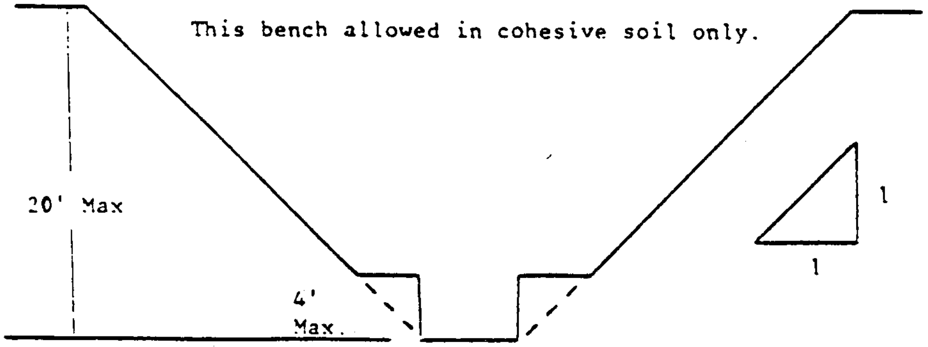
B-1.2 Excavations Made in Type B Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1.

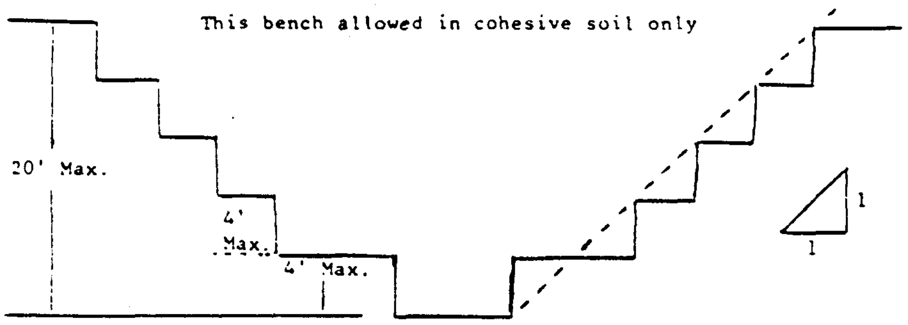


Simple Slope

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1:1 and maximum bench dimensions as follows:

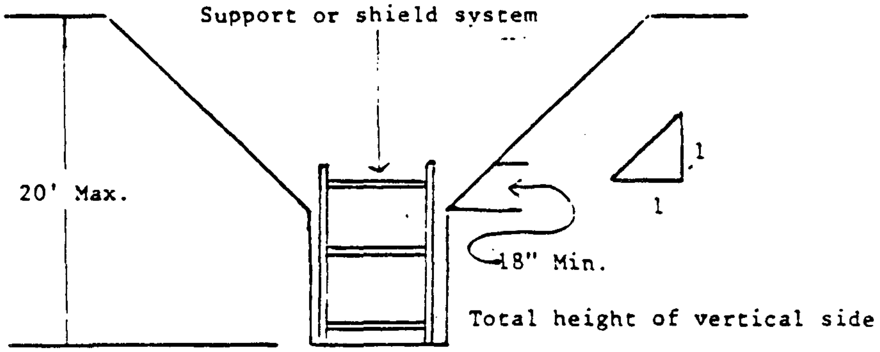


Single Bench



Multiple Bench

3. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1:1.

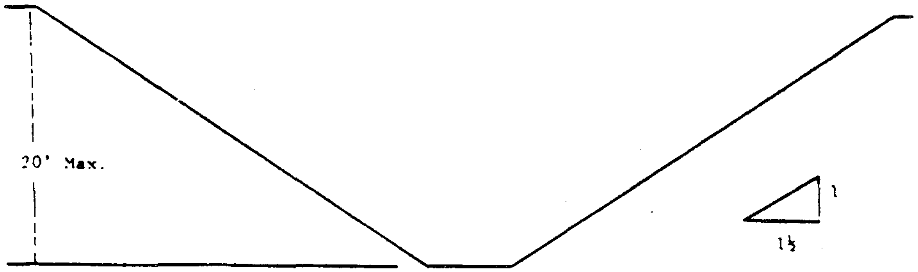


Vertically Sided Lower Portion

4. All other sloped excavations shall be in accordance with the other options permitted §1926.652(b).

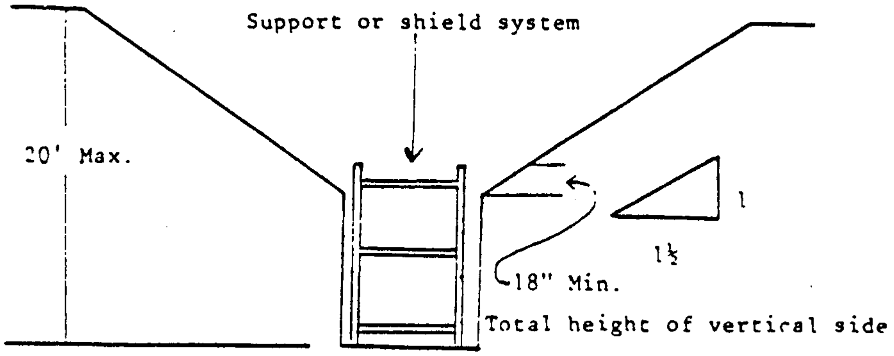
B-1.3 Excavations Made in Type C Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of 1½:1.



Simple Slope

2. All excavations 20 feet or less in depth which have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical side. All such excavations shall have a maximum allowable slope of 1½:1.

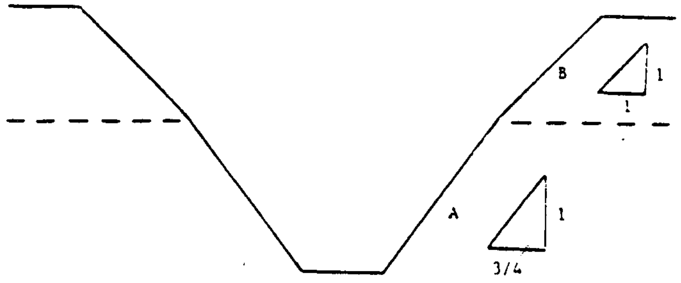


Vertical Sided Lower Portion

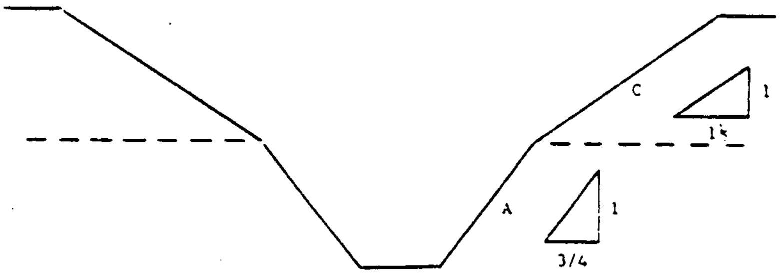
3. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

B-1.4 Excavations Made in Layered Soils

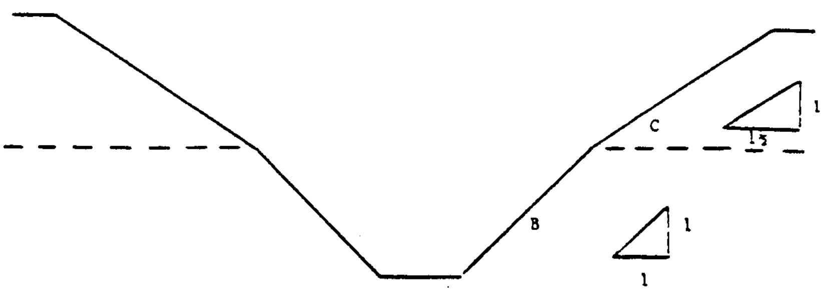
1. All excavations 20 feet or less in depth made in layered soils shall have a maximum allowable slope for each layer as set forth below.



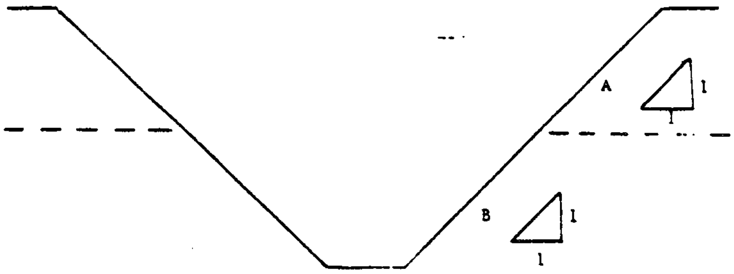
B OVER A



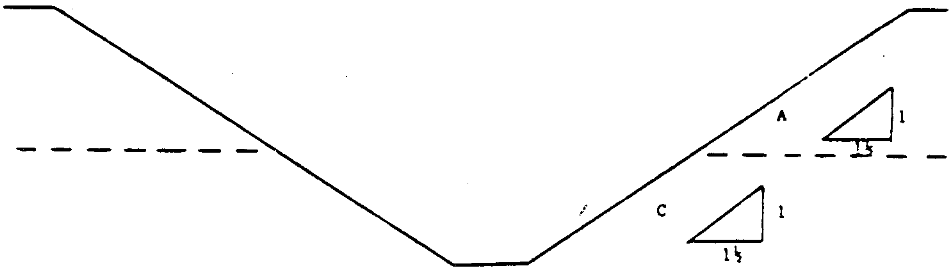
C OVER A



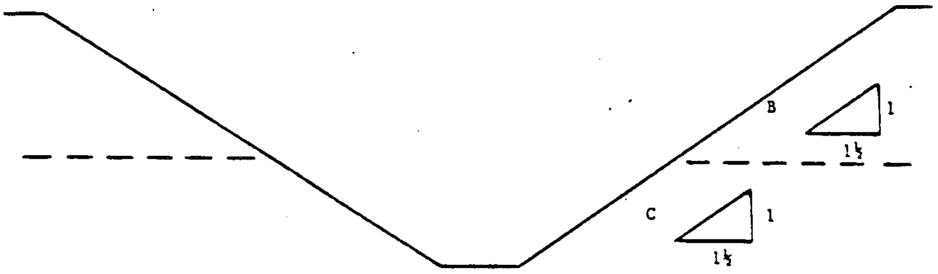
C OVER B



A OVER B



A OVER C



B OVER C

2. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

Appendix C to Subpart P

Timber Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used timber shoring is provided as a method of protection from cave-ins in trenches that do not exceed 20 feet (6.1 m) in depth. This appendix must be used when design of timber shoring protective systems is to be performed in accordance with §1926.652(c)(1). Other timber shoring configurations; other systems of support such as hydraulic and pneumatic systems; and other protective systems such as sloping, benching, shielding, and freezing systems must be designed in accordance with the requirements set forth in §1926.652(b) and §1926.652(c).

(b) *Soil Classification.* In order to use the data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of this part.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables C-1.1, C-1.2 and C-1.3, and Tables C-2.1, C-2.2, and C-2.3 following paragraph (g) of the appendix. Each table presents the minimum sizes of timber members to use in a shorting system, and each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. The data are arranged to allow the user the flexibility to select from among several acceptable configurations of members based on varying the horizontal spacing of the crossbraces. Stable rock is exempt from shoring requirements and therefore, no data are presented for this condition.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix, and on the tables themselves.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations regarding Tables C-1.1 through C-1.3 and Tables C-2.1 through C-2.3 are presented in paragraph (g) of this Appendix.

(d) *Basis and limitations of the data.*—(1) *Dimensions of timber members.* (i) The sizes of the timber members listed in Tables C-1.1 through C-1.3. are taken from the National Bureau of Standards (NBS) report, "Recommended Technical Provisions for Construction Practice in Shoring and Sloping of Trenches and Excavations." In addition, where NBS did not recommend specific sizes of members, member sizes are based on an analysis of the sizes required for use by existing codes and on empirical practice.

(ii) The required dimensions of the members listed in Tables C-1.1 through C-1.3 refer to actual dimensions and not nominal dimensions of the timber. Employers wanting to use nominal size shoring are directed to Tables C-2.1 through C-2.3, or have this choice under §1926.652(c)(3), and are referred to The Corps of Engineers. The Bureau of Reclamation or data from other acceptable sources.

(2) *Limitation of application.* (i) It is not intended that the timber shoring specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be designed as specified in §1926.652(c).

(ii) When any of the following conditions are present, the members specified in the tables are not considered adequate. Either an alternate timber shoring system must be designed or another type of protective system designed in accordance with §1926.652.

(A) When loads imposed by structures or by stored material adjacent to the trench weigh in excess of the load imposed by a two-foot soil surcharge. The term "adjacent" as used here means the area within a horizontal distance from the edge of the trench equal to the depth of the trench.

(B) When vertical loads imposed on cross braces exceed a 240-pound gravity load distributed on a one-foot section of the center of the crossbrace.

(C) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(D) When only the lower portion of a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables.* The members of the shoring system that are to be selected using this information are the cross braces, the uprights, and the wales, where wales are required. Minimum sizes of members are specified for use in different types of soil. There are six tables of information, two for each soil type. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is then made. The selection is based on the depth and width of the trench where the members are to be installed and, in most instances, the selection is also based on the horizontal spacing of the crossbraces. Instances where a choice of horizontal spacing of crossbracing is available, the horizontal spacing of the crossbraces must be chosen by the user before the size of any member can be determined. When the soil type, the width and depth of the trench, and the horizontal spacing of the crossbraces are known, the size and vertical spacing of the wales, and the size and horizontal spacing of the uprights can be read from the appropriate table.

(f) *Examples to Illustrate the Use of Tables C-1.1 through C-1.3.*

(1) *Example 1.*

A trench dug in Type A soil is 13 feet deep and five feet wide.

From *Table C-1.1,* for acceptable arrangements of timber can be used.

Arrangement #1

Space 4×4 crossbraces at six feet horizontally and four feet vertically.

Wales are not required.

Space 3×8 uprights at six feet horizontally. This arrangement is commonly called "skip shoring."

Arrangement # 2

Space 4×6 crossbraces at eight feet horizontally and four feet vertically.

Space 8×8 wales at four feet vertically.

Space 2×6 uprights at four feet horizontally.

Arrangement # 3

Space 6×6 crossbraces at 10 feet horizontally and four feet vertically.

Space 8×10 wales at four feet vertically.

Space 2×6 uprights at five feet horizontally.

Arrangement # 4

Space 6×6 crossbraces at 12 feet horizontally and four feet vertically.

Space 10×10 wales at four feet vertically.

Space 3×8 uprights at six feet horizontally.

(2) *Example 2.*

A trench dug in Type B soil in 13 feet deep and five feet wide. From Table C-1.2 three acceptable arrangements of members are listed.

Arrangement # 1

Space 6×6 crossbraces at six feet horizontally and five feet vertically.

Space 8×8 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement # 2

Space 6×8 crossbraces at eight feet horizontally and five feet vertically.

Space 10×10 wales at five feet vertically.

Space 2×6 uprights at two feet horizontally.

Arrangement # 3

Space 8×8 crossbraces at 10 feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Space 2×6 uprights at two feet vertically.

(3) *Example 3.*

A trench dug in Type C soil is 13 feet deep and five feet wide.

From Table C-1.3 two acceptable arrangements of members can be used.

Arrangement # 1

Space 8×8 crossbraces at six feet horizontally and five feet vertically.

Space 10×12 wales at five feet vertically.

Position 2×6 uprights as closely together as possible.

If water must be retained use special tongue and groove uprights to form tight sheeting.

Arrangement # 2

Space 8×10 crossbraces at eight feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Position 2×6 uprights in a close sheeting configuration unless water pressure must be resisted. Tight sheeting must be used where water must be retained.

(4) *Example 4.*

A trench dug in Type C soil is 20 feet deep and 11 feet wide. The size and spacing of members for the section of trench that is over 15 feet in depth is determined using Table C-1.3. Only one arrangement of members is provided.

Space 8×10 crossbraces at six feet horizontally and five feet vertically.

Space 12×12 wales at five feet vertically.

Use 3×6 tight sheeting.

Use of Tables C-2.1 through C-2.3 would follow the same procedures.

(g) *Notes for all Tables.*

1. Member sizes at spacings other than indicated are to be determined as specified in §1926.652(c), "Design of Protective Systems."

2. When conditions are saturated or submerged use Tight Sheeting. Tight Sheeting refers to the use of specially-edged timber planks (e.g., tongue and groove) at least three inches thick, steel sheet piling, or similar construction that when driven or placed in position provide a tight wall to resist the lateral pressure of water and to prevent the loss of backfill material. Close Sheeting refers to the placement of planks side-by-side allowing as little space as possible between them.

3. All spacing indicated is measured center to center.

4. Wales to be installed with greater dimension horizontal.

5. If the vertical distance from the center of the lowest crossbrace to the bottom of the trench exceeds two and one-half feet, uprights shall be firmly embedded or a mudsill shall be used. Where uprights are embedded, the vertical distance from the center of the lowest crossbrace to the bottom of the trench shall not exceed 36 inches. When mudsills are used, the vertical distance shall not exceed 42 inches. Mudsills are wales that are installed at the toe of the trench side.

6. Trench jacks may be used in lieu of or in combination with timber crossbraces.

7. Placement of crossbraces. When the vertical spacing of crossbraces is four feet, place the top crossbrace no more than two feet below the top of the trench. When the vertical spacing of crossbraces is five feet, place the top crossbrace no more than 2.5 feet below the top of the trench.

Table C-1.1

Timber Trench Shoring—Minimum Timber Requirements*

Soil Type A $P_a = 25 \times H + 72$ psf (2 ft Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4×4	4×4	4×6	6×6	6×6	4	Not Req'd	—				2×6	
	UP TO 8	4×4	4×4	4×6	6×6	6×6	4	Not Req'd	—					2×8
	UP TO 10	4×6	4×6	4×6	6×6	6×6	4	8×8	4			2×6		
	UP TO 12	4×6	4×6	6×6	6×6	6×6	4	8×8	4				2×6	
10 TO 15	UP TO 6	4×4	4×4	4×6	6×6	6×6	4	Not Req'd	—				3×8	
	UP TO 8	4×6	4×6	6×6	6×6	6×6	4	8×8	4		2×6			
	UP TO 10	6×6	6×5	6×6	6×8	6×8	4	8×10	4			2×6		
	UP TO 12	6×6	6×6	6×6	6×8	6×8	4	10×10	4				3×8	
15 TO 20	UP TO 6	6×6	6×6	6×6	6×8	6×8	4	6×8	4	3×6				
	UP TO 8	6×6	6×6	6×6	6×8	6×8	4	8×8	4	3×6				
	UP TO 10	8×8	8×8	8×8	8×8	8×10	4	8×10	4	3×6				
	UP TO 12	8×8	8×8	8×8	8×8	8×10	4	10×10	4	3×6				
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

Table C-1.2

Timber Trench Shoring—Minimum Timber Requirements*

Soil Type B $P_a = 45 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3		
5 TO 10	UP TO 6	4X6	4X6	6X6	6X6	6X6	5	6X8	5			2X6		
	UP TO 8	6X6	6X6	6X6	6X8	6X8	5	8X10	5			2X6		
	UP TO 10	6X6	6X6	6X6	6X8	6X8	5	10X10	5			2X6		
	See Note 1													
10 TO 15	UP TO 6	6X6	6X6	6X6	6X8	6X8	5	8X8	5		2X6			
	UP TO 8	6X8	6X8	6X8	8X8	8X8	5	10X10	5		2X6			
	UP TO 10	8X8	8X8	8X8	8X8	8X10	5	10X12	5		2X6			
	See Note 1													
15 TO 20	UP TO 6	6X8	6X8	6X8	8X8	8X8	5	8X10	5	3X6				
	UP TO 8	8X8	8X8	8X8	8X8	8X10	5	10X12	5	3X6				
	UP TO 10	8X10	8X10	8X10	8X10	10X10	5	12X12	5	3X6				
	See Note 1													
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

[Sec. 1926.652, Appendix C]

Table C-1.3

Timber Trench Shoring—Minimum Timber Requirements*

Soil Type C $P_a = 80 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (ACTUAL) AND SPACING OF MEMBERS**													
	CROSS BRACES									UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET) (See Note 2)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE				
5 TO 10	UP TO 6	6×8	6×8	6×8	8×8	8×8	5	8×10	5	2×6				
	UP TO 8	8×8	8×8	8×8	8×8	8×10	5	10×12	5	2×6				
	UP TO 10	8×10	8×10	8×10	8×10	10×10	5	12×12	5	2×6				
	See Note 1													
10 TO 15	UP TO 6	8×8	8×8	8×8	8×8	8×10	5	10×12	5	2×6				
	UP TO 8	8×10	8×10	8×10	8×10	10×10	5	12×12	5	2×6				
	See Note 1													
	See Note 1													
15 TO 20	UP TO 6	8×10	8×10	8×10	8×10	10×10	5	12×12	5	3×6				
	See Note 1													
	See Note 1													
	See Note 1													
OVER 20	SEE NOTE 1													

* Mixed oak or equivalent with a bending strength not less than 850 psi.

** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.1

Timber Trench Shoring—Minimum Timber Requirements*

Soil Type A $P_a = 25 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS**													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	4	5	6	8
5 TO 10	UP TO 6	4×4	4×4	4×4	4×4	4×6	4	Not Req'd	Not Req'd				4×6	
	UP TO 8	4×4	4×4	4×4	4×6	4×6	4	Not Req'd	Not Req'd					4×8
	UP TO 10	4×6	4×6	4×6	6×6	6×6	4	8×8	4			4×6		
	UP TO 12	4×6	4×6	4×6	6×6	6×6	4	8×8	4				4×6	
10 TO 15	UP TO 6	4×4	4×4	4×4	6×6	6×6	4	Not Req'd	Not Req'd				4×10	
	UP TO 8	4×6	4×6	4×6	6×6	6×6	4	6×8	4		4×6			
	UP TO 10	6×6	6×6	6×6	6×6	6×6	4	8×8	4			4×8		
	UP TO 12	6×6	6×6	6×6	6×6	6×6	4	8×10	4		4×6		4×10	
15 TO 20	UP TO 6	6×6	6×6	6×6	6×6	6×6	4	6×8	4	3×6				
	UP TO 8	6×6	6×6	6×6	6×6	6×6	4	8×8	4	3×6	4×12			
	UP TO 10	6×6	6×6	6×6	6×6	6×8	4	8×10	4	3×6				
	UP TO 12	6×6	6×6	6×6	6×8	6×8	4	8×12	4	3×6	4×12			
OVER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.2

Timber Trench Shoring—Minimum Timber Requirements*

Soil Type B $P_a = 45 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS**													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE	2	3	4	6
5 TO 10	UP TO 6	4×6	4×6	4×6	6×6	6×6	5	6×8	5			3×12 4×8		4×12
	UP TO 8	4×6	4×6	6×6	6×6	6×6	5	8×8	5		3×8		4×8	
	UP TO 10	4×6	4×6	6×6	6×6	6×8	5	8×10	5			4×8		
	See Note 1													
10 TO 15	UP TO 6	6×6	6×6	6×6	6×8	6×8	5	8×8	5	3×6	4×10			
	UP TO 8	6×8	6×8	6×8	8×8	8×8	5	10×10	5	3×6	4×10			
	UP TO 10	6×8	6×8	8×8	8×8	8×8	5	10×12	5	3×6	4×10			
	See Note 1													
15 TO 20	UP TO 6	6×8	6×8	6×8	6×8	8×8	5	8×10	5	4×6				
	UP TO 8	6×8	6×8	6×8	8×8	8×8	5	10×12	5	4×6				
	UP TO 10	8×8	8×8	8×8	8×8	8×8	5	12×12	5	4×6				
	See Note 1													
OVER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

Table C-2.3

Timber Trench Shoring—Minimum Timber Requirements*

Soil Type C $P_a = 80 \times H + 72$ psf (2 ft. Surcharge)

DEPTH OF TRENCH (FEET)	SIZE (S4S) AND SPACING OF MEMBERS**													
	CROSS BRACES							WALES		UPRIGHTS				
	HORIZ. SPACING (FEET)	WIDTH OF TRENCH (FEET)					VERT. SPACING (FEET)	SIZE (IN)	VERT. SPACING (FEET)	MAXIMUM ALLOWABLE HORIZONTAL SPACING (FEET)				
		UP TO 4	UP TO 6	UP TO 9	UP TO 12	UP TO 15				CLOSE				
5 TO 10	UP TO 6	6×6	6×6	6×6	6×6	8×8	5	8×8	5	3×6				
	UP TO 8	6×6	6×6	6×6	8×8	8×8	5	10×10	5	3×6				
	UP TO 10	6×6	6×6	8×8	8×8	8×8	5	10×12	5	3×6				
	See Note 1													
10 TO 15	UP TO 6	6×8	6×8	6×8	8×8	8×8	5	10×10	5	4×6				
	UP TO 8	8×8	8×8	8×8	8×8	8×8	5	12×12	5	4×6				
	See Note 1													
	See Note 1													
15 TO 20	UP TO 6	8×8	8×8	8×8	8×10	8×10	5	10×12	5	4×6				
	See Note 1													
	See Note 1													
	See Note 1													
OVER 20	SEE NOTE 1													

* Douglas fir or equivalent with a bending strength not less than 1500 psi.

** Manufactured members of equivalent strength may be substituted for wood.

Appendix D To Subpart P

Aluminum Hydraulic Shoring for Trenches

(a) *Scope.* This appendix contains information that can be used when aluminum hydraulic shoring is provided as a method of protection against cave-ins in trenches that do not exceed 20 feet (6.1m) in depth. This appendix must be used when design of the aluminum hydraulic protective system cannot be performed in accordance with §1926.652(c)(2).

(b) *Soil Classification.* In order to use data presented in this appendix, the soil type or types in which the excavation is made must first be determined using the soil classification method set forth in appendix A of subpart P of part 1926.

(c) *Presentation of Information.* Information is presented in several forms as follows:

(1) Information is presented in tabular form in Tables D-1.1, D -1.2, D -1.3 and E -1.4. Each table presents the maximum vertical and horizontal spacings that may be used with various aluminum member sizes and various hydraulic cylinder sizes. Each table contains data only for the particular soil type in which the excavation or portion of the excavation is made. Tables D-1.1 and D -1.2 are for vertical shores in Types A and B soil. Tables D-1.3 and D -1.4 are for horizontal waler systems in Types B and C soil.

(2) Information concerning the basis of the tabular data and the limitations of the data is presented in paragraph (d) of this appendix.

(3) Information explaining the use of the tabular data is presented in paragraph (e) of this appendix.

(4) Information illustrating the use of the tabular data is presented in paragraph (f) of this appendix.

(5) Miscellaneous notations (footnotes) regarding Table D-1.1 through D -1.4 are presented in paragraph (g) of this appendix.

(6) Figures, illustrating typical installations of hydraulic shoring, are included just prior to the Tables. The illustrations page is entitled "Aluminum Hydraulic Shoring: Typical Installations."

(d) *Basis and limitations of the data.*

(1) Vertical shore rails and horizontal wales are those that meet the Section Modulus requirements in the D-1 Tables. Aluminum material is 6060 -T6 or material of equivalent strength and properties.

(2) Hydraulic cylinders specifications. (i) 2-inch cylinders shall be a minimum safe working capacity of no less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe working capacity of not less than 30,000 pounds axial compressive load at extensions as recommended by product manufacturer.

(3) Limitation of application.

(i) It is not intended that the aluminum hydraulic specification apply to every situation that may be experienced in the field. These data were developed to apply to the situations that are most commonly experienced in current trenching practice. Shoring systems for use in situations that are not covered by the data in this appendix must be otherwise designed as specified in §1926.652(c).

(ii) When any of the following conditions are present, the members specified in the Tables are not considered adequate. In this case, an alternative aluminum hydraulic shoring system or other type of protective system must be designed in accordance with §1926.652.

(A) When vertical loads imposed on cross braces exceed a 100 Pound gravity load distributed on a one foot section of the center of the hydraulic cylinder.

(B) When surcharge loads are present from equipment weighing in excess of 20,000 pounds.

(C) When only the lower portion or a trench is shored and the remaining portion of the trench is sloped or benched unless: The sloped portion is sloped at an angle less steep than three horizontal to one vertical; or the members are selected from the tables for use at a depth which is determined from the top of the overall trench, and not from the toe of the sloped portion.

(e) *Use of Tables D-1.2, D-1.3 and D-1.4.* The members of the shoring system that are to be selected using this information are the hydraulic cylinders, and either the vertical shores or the horizontal wales. When a waler system is used the vertical timber sheeting to be used is also selected from these tables. The Tables D-1.1 and D -1.2 for vertical shores are used in Type A and B soils that do not require sheeting. Type B soils that may require sheeting, and Type C soils that always require sheeting are found in the horizontal wale Tables D-1.3 and D -1.4. The soil type must first be determined in accordance with the soil classification system described in appendix A to subpart P of part 1926. Using the appropriate table, the selection of the size and spacing of the members is made. The selection is based on the depth and width of the trench where the members are to be installed. In these tables the vertical spacing is held constant at four feet on center. The tables show the maximum horizontal spacing of cylinders allowed for each size of wale in the waler system tables, and in the vertical shore tables, the hydraulic cylinder horizontal spacing is the same as the vertical shore spacing.

(f) *Example to Illustrate the Use of the Tables*:

(1) Example 1:

A trench dug in Type A soil is 6 feet deep and 3 feet wide. From Table D -1.1: Find vertical shores and 2 inch diameter cylinders spaced 8 feet on center (o.c.) horizontally and 4 feet on center (o.c.) vertically. (See Figures 1 & 3 for typical installations.)

(2) Example 2:

A trench is dug in Type B soil that does not require sheeting, 13 feet deep and 5 feet wide. From Table D -1.2: Find vertical shores and 2 inch diameter cylinders spaced 6.5 feet o.c. horizontally and 4 feet o.c. vertically. (See Figures 1 & 3 for typical installations.)

(3) A trench is dug in Type B soil that does not require sheeting, but does experience some minor raveling of the trench face. The trench is 16 feet deep and 9 feet wide. From Table D -1.2: Find vertical shores and 2 inch diameter cylinder (with special oversleeves as designated by footnote # 2) spaced 5.5 feet o.c. horizontally and 4 feet o.c. vertically, plywood (per footnote (g)(7) to the D -1 Table) should be used behind the shores. (See Figures 2 & 3 for typical installations.)

(4) Example 4: A trench is dug in previously disturbed Type B soil, with characteristics of a Type C soil, and will require sheeting. The trench is 18 feet deep and 12 feet wide. 8 foot horizontal spacing between cylinders is desired for working space. From Table D -1.3: Find horizontal wale with a section modulus of 14.0 spaced at 4 feet o.c. vertically and 3 inch diameter cylinder spaced at 9 feet maximum o.c. horizontally. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(5) Example 5: A trench is dug in Type C soil, 9 feet deep and 4 feet wide. Horizontal cylinder spacing in excess of 6 feet is desired for working space. From Table D -1.4: Find horizontal wale with a section modulus of 7.0 and 2 inch diameter cylinders spaced at 6.5 feet o.c. horizontally. Or, find horizontal wale with a 14.0 section modulus and 3 inch diameter cylinder spaced at 10 feet o.c. horizontally. Both wales are spaced 4 feet o.c. vertically. 3×12 timber sheeting is required at close spacing vertically. (See Figure 4 for typical installation.)

(g) *Footnotes, and general notes, for Tables D-1.1, D-1.2, D -1.3, and D-1.4.*

(1) For applications other than those listed in the tables, refer to §1926.652(c)(2) for use of manufacturer's tabulated data. For trench depths in excess of 20 feet, refer to §1926.652(c)(2) and §1926.652(c)(3).

(2) 2 inch diameter cylinders, at this width, shall have structural steel tube (3.5×3.5×0.1875) oversleeves, or structural oversleeves of manufacturer's specification, extending the full, collapsed length.

(3) Hydraulic cylinders capacities. (i) 2 inch cylinders shall be a minimum 2-inch inside diameter with a safe working capacity of not less than 18,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(ii) 3-inch cylinders shall be a minimum 3-inch inside diameter with a safe work capacity of not less than 30,000 pounds axial compressive load at maximum extension. Maximum extension is to include full range of cylinder extensions as recommended by product manufacturer.

(4) All spacing indicated is measured center to center.

(5) Vertical shorting rails shall have a minimum section modulus of 0.40 inch.

(6) When vertical shores are used, there must be a minimum of three shores spaced equally, horizontally, in a group.

(7) Plywood shall be 1.125 in. thick softwood or 0.75 inch, thick, 14 ply, arctic white birch (Finland form). Please note that plywood is not intended as a structural mem-

ber, but only for prevention of local raveling (sloughing of the trench face) between shores.

(8) See appendix C for timber specifications.

(9) Wales are calculated for simple span conditions.

(10) See appendix D, item (d), for basis and limitations of the data.

Aluminum Hydraulic Shoring

Typical Installations

FIGURE NO. 1

VERTICAL ALUMINUM HYDRAULIC SHORING (SPOT BRACING)

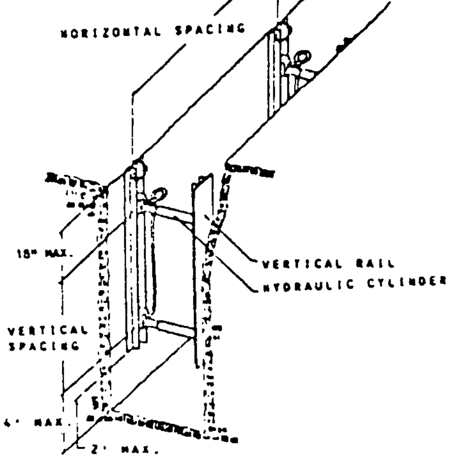


FIGURE NO. 2

VERTICAL ALUMINUM HYDRAULIC SHORING (WITH PLYWOOD)

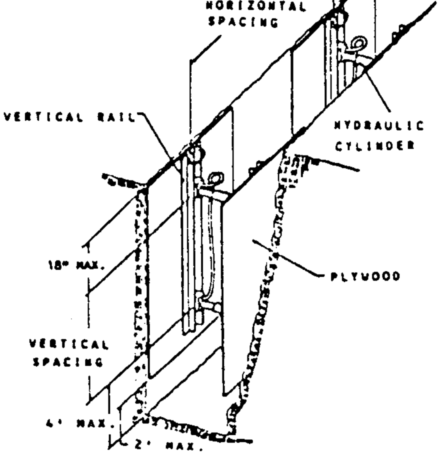


FIGURE NO. 3

VERTICAL ALUMINUM HYDRAULIC SHORING (STACKED)

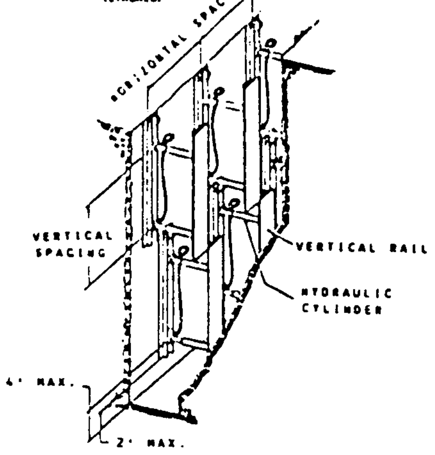


FIGURE NO. 4

ALUMINUM HYDRAULIC SHORING WALER SYSTEM (TYPICAL)

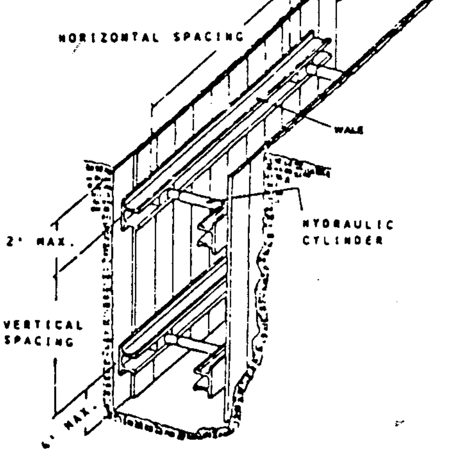


Table D-1.1

Aluminum Hydraulic Shoring

Vertical Shores

For Soil Type A

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 10 UP TO 15	8				
OVER 15 UP TO 20	7				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g)(1)
Note (2): See Appendix D, Item (g)(2)

Table D-1.2

Aluminum Hydraulic Shoring

Vertical Shores

For Soil Type B

DEPTH OF TRENCH (FEET)	HYDRAULIC CYLINDERS				
	MAXIMUM HORIZONTAL SPACING (FEET)	MAXIMUM VERTICAL SPACING (FEET)	WIDTH OF TRENCH (FEET)		
			UP TO 8	OVER 8 UP TO 12	OVER 12 UP TO 15
OVER 5 UP TO 10	8	4	2 INCH DIAMETER	2 INCH DIAMETER NOTE (2)	3 INCH DIAMETER
OVER 10 UP TO 15	6.5				
OVER 15 UP TO 20	5.5				
OVER 20	NOTE (1)				

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Note (1): See Appendix D, Item (g)(1)
Note (2): See Appendix D, Item (g)(2)

Table D-1.3

Aluminum Hydraulic Shoring

Waler Systems

For Soil Type B

	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
			WIDTH OF TRENCH (FEET)						MAX. HORIZ. SPACING (ON CENTER)		
DEPTH OF TRENCH	VERTICAL SPACING	* SECTION MODULUS	UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15		SOLID SHEET	2 FT.	3 FT.
(FEET)	(FEET)	(IN^3)	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	8.0	2 IN	8.0	2 IN NOTE (2)	8.0	3 IN	—	—	3×12
		7.0	9.0	2 IN	9.0	2 IN NOTE (2)	9.0	3 IN			
		14.0	12.0	3 IN	12.0	3 IN	12.0	3 IN			
OVER 10 UP TO 15	4	3.5	6.0	2 IN	6.0	2 IN NOTE (2)	6.0	3 IN	—	3×12	—
		7.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 15 UP TO 20	4	3.5	5.5	2 IN	5.5	2 IN NOTE (2)	5.5	3 IN	3×12	—	—
		7.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
		14.0	9.0	3 IN	9.0	3 IN	9.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, item (g)(1)
Notes (2): See Appendix D, item (g)(2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

Table D-1.4
Aluminum Hydraulic Shoring
Waler Systems
For Soil Type C

DEPTH OF TRENCH (FEET)	WALES		HYDRAULIC CYLINDERS						TIMBER UPRIGHTS		
	VERTICAL SPACING (FEET)	* SECTION MODULUS (IN^3)	WIDTH OF TRENCH (FEET)						MAX. HORIZ. SPACING (ON CENTER)		
			UP TO 8		OVER 8 UP TO 12		OVER 12 UP TO 15		SOLID SHEET	2 FT.	3 FT.
			HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER	HORIZ. SPACING	CYLINDER DIAMETER			
OVER 5 UP TO 10	4	3.5	6.0	2 IN	6.0	2 IN NOTE (2)	6.0	3 IN	3×12	—	—
		7.0	6.5	2 IN	6.5	2 IN NOTE (2)	6.5	3 IN			
		14.0	10.0	3 IN	10.0	3 IN	10.0	3 IN			
OVER 10 UP TO 15	4	3.5	4.0	2 IN	4.0	2 IN NOTE (2)	4.0	3 IN	3×12	—	—
		7.0	5.5	3 IN	5.5	3 IN	5.5	3 IN			
		14.0	8.0	3 IN	8.0	3 IN	8.0	3 IN			
OVER 15 UP TO 20	4	3.5	3.5	2 IN	3.5	2 IN NOTE (2)	3.5	3 IN	3×12	—	—
		7.0	5.0	3 IN	5.0	3 IN	5.0	3 IN			
		14.0	6.0	3 IN	6.0	3 IN	6.0	3 IN			
OVER 20	NOTE (1)										

Footnotes to tables, and general notes on hydraulic shoring, are found in Appendix D, Item (g)
Notes (1): See Appendix D, item (g)(1)
Notes (2): See Appendix D, item (g)(2)
* Consult product manufacturer and/or qualified engineer for Section Modulus of available wales.

Appendix E to Subpart P—Alternatives to Timber Shoring

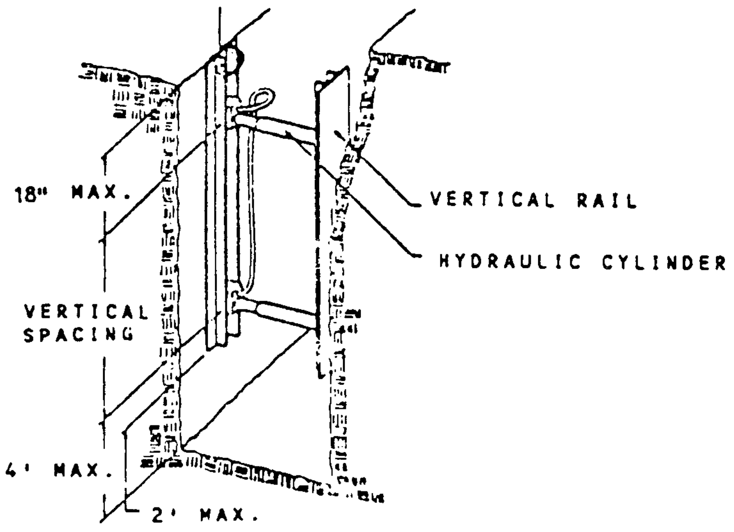
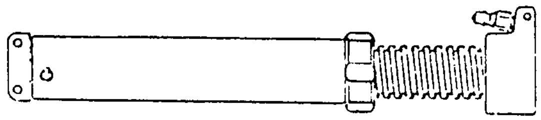


Figure 1. Aluminum Hydraulic Shoring



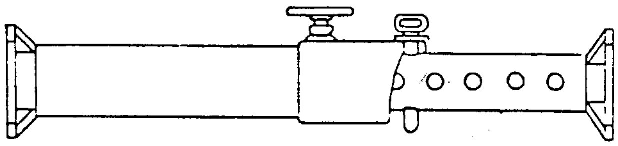


Figure 2. Pneumatic/Hydraulic Shoring

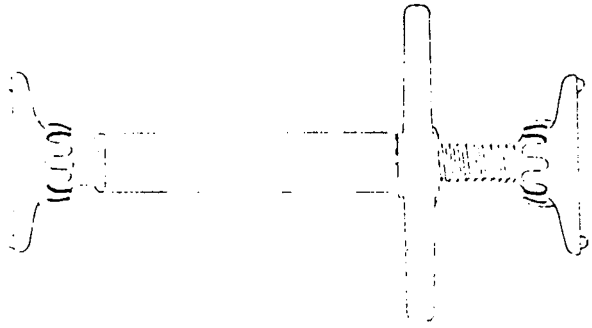


Figure 3. Trench Jacks (Screw Jacks)

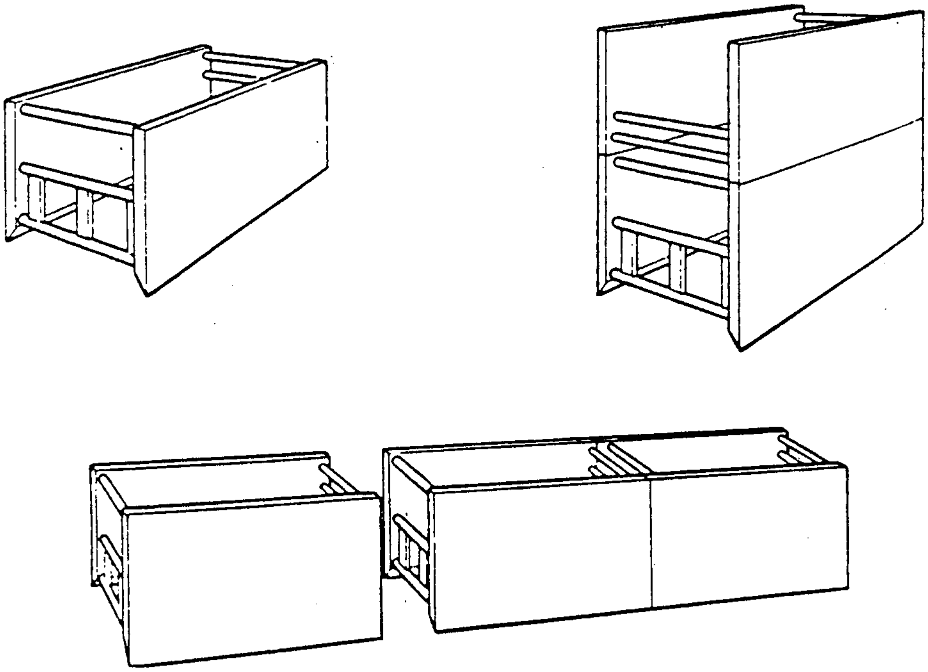


Figure 4. Trench Shields

Appendix F to Subpart P—Selection of Protective Systems

The following figures are a graphic summary of the requirements contained in subpart P for excavations 20 feet or less in depth. Protective systems for use in excavations more than 20 feet in depth must be designed by a registered professional engineer in accordance with §1926.652(b) and (c).

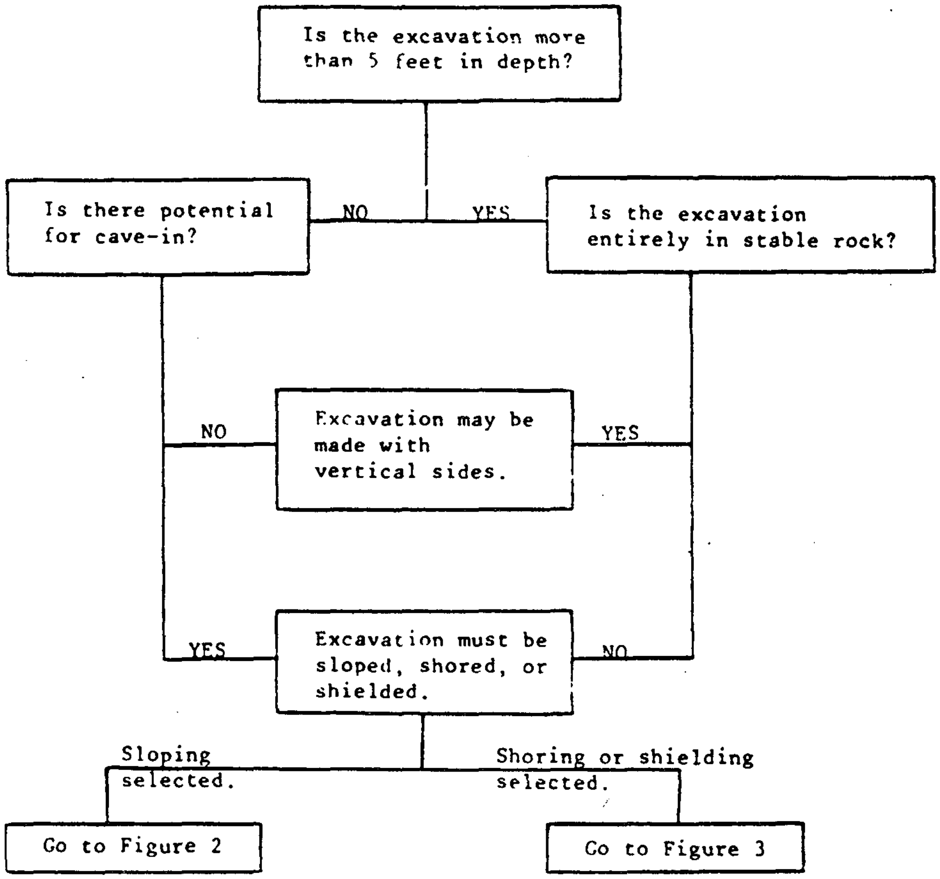


Figure 1—Preliminary Decisions

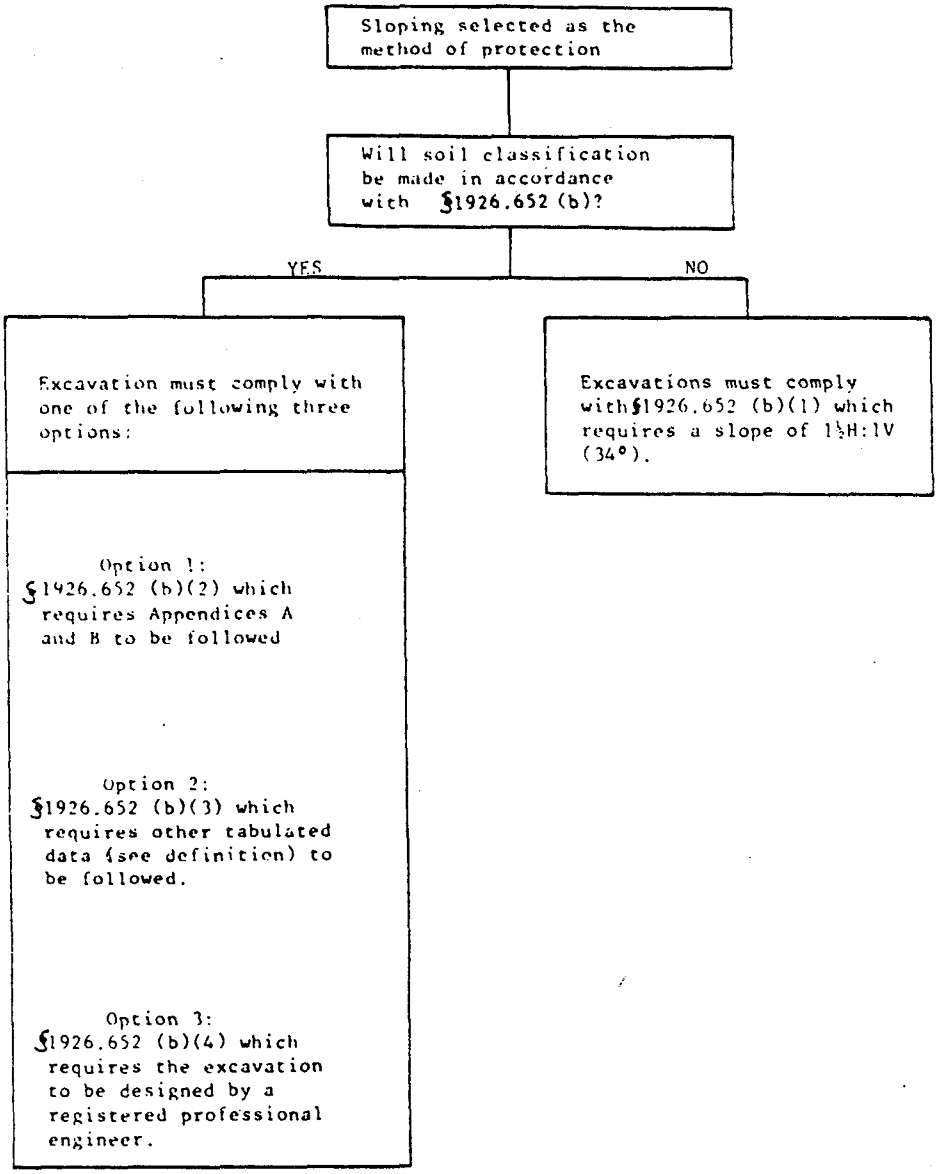
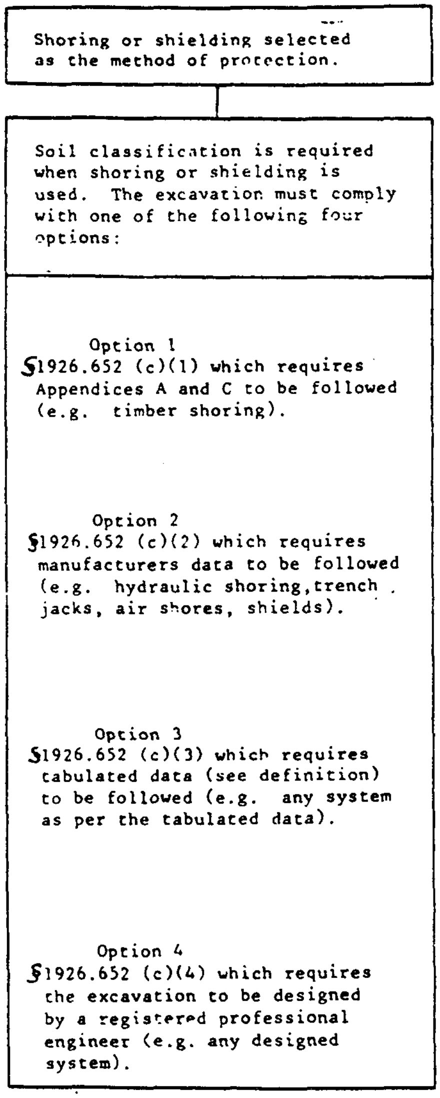


Figure 2—Sloping Options



Shoring or shielding selected as the method of protection.

Soil classification is required when shoring or shielding is used. The excavation must comply with one of the following four options:

Option 1
§1926.652 (c)(1) which requires Appendices A and C to be followed (e.g. timber shoring).

Option 2
§1926.652 (c)(2) which requires manufacturers data to be followed (e.g. hydraulic shoring, trench jacks, air shores, shields).

Option 3
§1926.652 (c)(3) which requires tabulated data (see definition) to be followed (e.g. any system as per the tabulated data).

Option 4
§1926.652 (c)(4) which requires the excavation to be designed by a registered professional engineer (e.g. any designed system).

Figure 3—Shoring and Shielding Options

Subpart Q—Concrete and Masonry Construction

Authority note: Sec. 107, Contract Work Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); Secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, and 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), 9-83 (48 FR 35736), or 1-90 (55 FR 9033), as applicable.

[Authority citation for Subpart Q revised by 55 FR 42328, October 18, 1990; 59 FR 40730, August 9, 1994]

Source: 53 FR 22643, June 16, 1988, unless otherwise noted.

§1926.700 Scope, application, and definitions applicable to this subpart.

(a) *Scope and application.* This subpart sets forth requirements to protect all construction employees from the hazards associated with concrete and masonry construction operations performed in workplaces covered under 29 CFR Part 1926. In addition to the requirements in Subpart Q, other relevant provisions in Parts 1910 and 1926 apply to concrete and masonry construction operations.

(b) *Definitions applicable to this subpart.* In addition to the definitions set forth in §1926.32, the following definitions apply to this subpart.

(1) "Bull float" means a tool used to spread out and smooth concrete.

(2) "Formwork" means the total system of support for freshly placed or particularly cured concrete, including the mold or sheeting (form) that is in contact with the concrete as well as all supporting members including shores, reshores, hardware, braces, and related hardware.

(3) "Lift slab" means a method of concrete construction in which floor, and roof slabs are cast on or at ground level and, using jacks, lifted into position.

(4) "Limited access zone" means an area alongside a masonry wall, which is under construction, and which is clearly demarcated to limit access by employees.

(5) "Precast concrete" means concrete members (such as walls, panels, slabs, columns, and beams) which have been formed, cast, and cured prior to final placement in a structure.

(6) "Reshoring" means the construction operation in which shoring equipment (also called reshores or reshoring equipment) is placed, as the original forms and shores are removed, in order to support partially cured concrete and construction loads.

(7) "Shore" means a supporting member that resists a compressive force imposed by a load.

(8) "Vertical slip forms" means forms which are jacked vertically during the placement of concrete.

(9) *Jacking operation* means the task of lifting a slab (or group of slabs) vertically from one location to another (e.g., from the casting location to a temporary (parked) location, or from a temporary location to another temporary location, or to its final location in the structure), during the construction of a building/structure where the lift-slab process is being used.

[Sec. 1926.700(b)(9) added by 55 FR 42328, October 18, 1990]

§1926.701 General requirements

(a) *Construction loads* . No construction loads shall be placed on a concrete structure or portion of a concrete structure unless the employer determines, based on information received from a person who is qualified in structural design, that the structure or portion of the structure is capable of supporting the loads.

(b) *Reinforcing steel.* All protruding reinforcing steel, onto and into which employees could fall, shall be guarded to eliminate the hazard of impalement.

(c) *Post-tensioning operations.* (1) No employee (except those essential to the post-tensioning operations) shall be permitted to be behind the jack during tensioning operations.

(2) Signs and barriers shall be erected to limit employee access to the post-tensioning area during tensioning operations.

(d) *Riding concrete buckets* . No employee shall be permitted to ride concrete buckets.

(e) *Working under loads.* (1) No employee shall be permitted to work under concrete buckets while buckets are being elevated or lowered into position.

(2) To the extent practical, elevated concrete buckets shall be routed so that no employee, or the fewest number of employees, are exposed to the hazards associated with falling concrete buckets.

(f) *Personal protective equipment.* No employee shall be permitted to apply a cement, sand, and water mixture through a pneumatic hose unless the employee is wearing protective head and face equipment.

[1926.701(f)(1) designation and (2) removed by 59 FR 40729, August 9, 1994]

§1926.702 Requirements for equipment and tools.

(a) *Bulk cement storage.* (1) Bulk storage bins, containers, and silos shall be equipped with the following:

(i) Conical or tapered bottoms; and

(ii) Mechanical or pneumatic means of starting the flow of material.

(2) No employee shall be permitted to enter storage facilities unless the ejection system has been shut down, locked out, and tagged to indicate that the ejection system is not to be operated.

(b) *Concrete mixers.* Concrete mixers with one cubic yard (.8m ^{3}) or larger loading skips shall be equipped with the following:

(1) A mechanical device to clear the skip of materials; and

(2) Guardrails installed on each side of the skip.

(c) *Power concrete trowels.* Powered and rotating type concrete troweling machines that are manually guided shall be equipped with a control switch that will

Appendix D

Electrical Safety

be capable of putting rescue operations into effect.

[1926.353(b)(3) added by 58 FR 35077, June 30, 1993]

(c) *Welding, cutting, or heating of metals of toxic significance.* (1) Welding, cutting, or heating in any enclosed spaces involving the metals specified in this subparagraph shall be performed with either general mechanical or local exhaust ventilation meeting the requirements of paragraph (a) of this section:

(i) Zinc-bearing base or filler metals or metals coated with zinc-bearing materials;

(ii) Lead base metals;

(iii) Cadmium-bearing filler materials;

(iv) Chromium-bearing metals or metals coated with chromium-bearing materials.

(2) Welding, cutting, or heating in any enclosed spaces involving the metals specified in this subparagraph shall be performed with local exhaust ventilation in accordance with the requirements of paragraph (a) of this section, or employees shall be protected by air line respirators in accordance with the requirements of Subpart E of this part:

(i) Metals containing lead, other than as an impurity, or metals coated with lead-bearing materials;

(ii) Cadmium-bearing or cadmium-coated base metals;

(iii) Metals coated with mercury-bearing metals;

(iv) Beryllium-containing base or filler metals. Because of its high toxicity, work involving beryllium shall be done with both local exhaust ventilation and air line respirators.

(3) Employees performing such operations in the open air shall be protected by filter-type respirators in accordance with the requirements of Subpart E of this part, except that employees performing such operations on beryllium-containing base or filler metals shall be protected by air line respirators in accordance with the requirements of Subpart E of this part.

(4) Other employees exposed to the same atmosphere as the welders or burners shall be protected in the same manner as the welder or burner.

(d) *Inert-gas metal-arc welding.* (1) Since the inert-gas metal-arc welding process involves the production of ultra-violet radiation of intensities of 5 to 30 times that produced during shielded metal-arc welding, the decomposition of chlorinated solvents by ultraviolet rays, and the liberation of toxic fumes and gases, employees shall not be permitted to engage in or be exposed to the process until the following special precautions have been taken:

(i) The use of chlorinated solvents shall be kept at least 200 feet, unless shielded, from the exposed arc, and surfaces prepared with chlorinated solvents shall be thoroughly dry before welding is permitted on such surfaces.

(ii) Employees in the area not protected from the arc by screening shall be protected by filter lenses meeting the requirements of Subpart E of this part. When two or more welders are exposed to each other's arc, filter lens goggles of a suitable type, meeting the requirements of Subpart E of this part, shall be worn under welding helmets. Hand shields to protect the welder against flashes and radiant energy shall be used when either the helmet is lifted or the shield is removed.

(iii) Welders and other employees who are exposed to radiation shall be suitably protected so that the skin is covered completely to prevent burns and other damage by ultraviolet rays. Welding helmets and hand shields shall be free of leaks and openings, and free of highly reflective surfaces.

(iv) When inert-gas metal-arc welding is being performed on stainless steel, the requirements of paragraph (c)(2) of this section shall be met to protect against dangerous concentrations of nitrogen dioxide.

(e) *General welding, cutting, and heating.* (1) Welding, cutting, and heating, not involving conditions or materials described in paragraph (b), (c), or (d) of this section, may normally be done without mechanical ventilation or respiratory protective equipment, but where, because of unusual physical or atmospheric conditions, an unsafe accumulation of contaminants exists, suitable mechanical ventilation or respiratory protective equipment shall be provided.

(2) Employees performing any type of welding, cutting, or heating shall be protected by suitable eye protective equipment in accordance with the requirements of Subpart E of this part.

§1926.354 Welding, cutting, and heating in way of preservative coatings.

(a) Before welding, cutting, or heating is commenced on any surface covered by a preservative coating whose flammability is not known, a test shall be made by a competent person to determine its flammability. Preservative coatings shall be considered to be highly flammable when scrapings burn with extreme rapidity.

(b) Precautions shall be taken to prevent ignition of highly flammable hardened preservative coatings. When coatings are determined to be highly flammable they shall be stripped from the area to be heated to prevent ignition.

(c) Protection against toxic preservative coatings. (1) In enclosed spaces, all surfaces covered with toxic preservatives shall be stripped of all toxic coatings for a distance of at least 4 inches from the area of heat application, or the employees shall be protected by air line respirators, meeting the requirements of Subpart E of this part.

(2) In the open air, employees shall be protected by a respirator, in accordance with requirements of Subpart E of this part.

(d) The preservative coatings shall be removed a sufficient distance from the area to be heated to ensure that the temperature of the unstripped metal will not be appreciably raised. Artificial cooling of the metal surrounding the heating area may be used to limit the size of the area required to be cleaned.

Subpart K—Electrical

Authority: Secs. 6 and 8, Occupational Safety and Health Act (29 U.S.C. 655, 657); sec. 107, Contract Work Hours and Safety Standards Act (40 U.S.C. 333); Secretary of Labor's Order No. 9-83 (48 FR 35736); 29 CFR Part 1911.

[Authority citation for Subpart K added by 51 FR 25318, July 11, 1986]

General

§1926.400 Introduction.

This subpart addresses electrical safety requirements that are necessary for the practical safeguarding of employees involved in construction work and is divided into four major divisions and applicable definitions as follows:

(a) *Installation safety requirements.* Installation safety requirements are contained in §§1926.402 through 1926.408. Included in this category are electric equipment and installations used to provide electric power and light on jobsites.

(b) *Safety-related work practices.* Safety-related work practices are contained in §§1926.416 and 1926.417. In addition to covering the hazards arising from the use of electricity at jobsites, these regulations also cover the hazards arising from the accidental contact, direct or indirect, by employees with all energized lines, above or below ground, passing through or near the jobsite.

(c) *Safety-related maintenance and environmental considerations.* Safety-related maintenance and environmental considerations are contained in §§1926.431 and 1926.432.

(d) *Safety requirements for special equipment.* Safety requirements for special equipment are contained in §1926.441.

(e) *Definitions.* Definitions applicable to this Subpart are contained in §1926.449.

§1926.401 [Reserved]

Installation Safety Requirements

§1926.402 Applicability.

(a) *Covered.* Sections 1926.402 through 1926.408 contain installation safety requirements for electrical equipment and installations used to provide electric power and light at the jobsite. These sections apply to installations, both temporary and permanent, used on the jobsite; but these sections do not apply to existing permanent installations that were in place before the construction activity commenced.

Note: If the electrical installation is made in accordance with the National Electrical Code ANSI/NFPA 70-1984, exclusive of Formal Interpretations and Tentative Interim Amendments, it will be deemed to be in compliance with §§1926.403 through 1926.408 except for §§1928.404(b)(1) and 1926.405 (a)(2)(ii)(E), (F), (G), and (j).

(b) *Not covered.* Sections 1926.402 through 1926.408 do not cover installations used for the generation, transmission, and distribution of electric energy, including related communication, metering, control, and transformation installations. (However, these regulations do cover portable and vehicle-mounted generators used to provide power for equipment used at the jobsite.) See Subpart V of this Part for the construction of power distribution and transmission lines.

§1926.403 General requirements.

(a) *Approval.* All electrical conductors and equipment shall be approved.

(b) *Examination, installation, and use of equipment*—(1) *Examination.* The employer shall ensure that electrical equipment is free from recognized hazards that are likely to cause death or serious physical harm to employees. Safety of equipment shall be determined on the basis of the following considerations;

(i) Suitability for installation and use in conformity with the provisions of this subpart. Suitability of equipment for an identified purpose may be evidenced by listing, labeling, or certification for that identified purpose.

(ii) Mechanical strength and durability, including, for parts designed to enclose and protect other equipment, the adequacy of the protection thus provided.

(iii) Electrical insulation.

(iv) Heating effects under conditions of use.

(v) Arcing effects.

(vi) Classification by type, size, voltage, current capacity, specific use.

(vii) Other factors which contribute to the practical safeguarding of employees using or likely to come in contact with the equipment.

(2) *Installation and use.* Listed, labeled, or certified equipment shall be installed and used in accordance with instructions included in the listing, labeling, or certification.

(c) *Interrupting rating.* Equipment intended to break current shall have an interrupting rating at system voltage sufficient for the current that must be interrupted.

(d) *Mounting and cooling of equipment*—(1) *Mounting.* Electric equipment shall be firmly secured to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used.

(2) *Cooling.* Electrical equipment which depends upon the natural circulation of air and convection principles for cooling of exposed surfaces shall be installed so that room air flow over such surfaces is not prevented by walls or by adjacent installed equipment. For equipment designed for floor mounting, clearance between top surfaces and adjacent surfaces shall be provided to dissipate rising warm air. Electrical equipment provided with ventilating openings shall be installed so that walls or other obstructions do not prevent the free circulation of air through the equipment.

(e) *Splices.* Conductors shall be spliced or joined with splicing devices designed for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall first be so spliced or joined as to be mechanically and electrically secure without solder and then soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an insulating device designed for the purpose.

(f) *Arcing parts.* Parts of electric equipment which in ordinary operation produce arcs, sparks, flames, or molten metal shall be enclosed or separated and isolated from all combustible material.

(g) *Marking.* Electrical equipment shall not be used unless the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified is placed on the equipment and unless other markings are provided giving voltage, current, wattage, or other ratings as necessary. The marking shall be of sufficient, durability to withstand the environment involved.

(h) *Identification of disconnecting means and circuits.* Each disconnecting means required by this subpart for motors and appliances shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. Each service, feeder, and branch circuit, at its disconnecting means or overcurrent device, shall be legibly marked to indicate its purpose, unless located and arranged so the purpose is evident. These markings shall be of sufficient durability to withstand the environment involved.

(i) *600 Volts, nominal or less.* This paragraph applies to equipment operating at 600 volts, nominal, or less.

(1) *Working space about electric equipment.* Sufficient access and working space shall be provided and maintained about all electric equipment to permit ready and safe operation and maintenance of such equipment.

(i) *Working clearances.* Except as required or permitted elsewhere in this subpart, the dimension of the working space in the direction of access to live parts operating at 600 volts or less and likely to require examination, adjustment, servicing, or maintenance while alive shall not be less than indicated in Table K-1. In addition to the dimensions shown in Table K-1, workspace shall not be less than 30 inches (762 mm) wide in front of the electric equipment. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. Walls constructed of concrete, brick, or tile are considered to be grounded. Working space is not required in back of assemblies such as dead-front switchboards or motor control centers where there are no renewable or adjustable parts such as fuses or switches on the back and where all connections are accessible from locations other than the back.

Table K-1—Working Clearances

Nominal voltage to ground	Minimum clear distance for conditions[1]		
	(a)	(b)	(c)
	Feet[2]	Feet[2]	Feet[2]
0-150	3	3	3
151-600	3	3½	4

[1] Conditions (a), (b), and (c) are as follows: (a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating material. Insulated wire or insulate busbars operating at not over 300 volts are not considered live parts. (b) Exposed live parts on one side and grounded parts on the other side. (c) Exposed live parts on both sides of the workspace [not guarded as provided in Condition (a) with the operator between.

[2] Note: For International System of Units (SI): one foot=0.3048m.

(ii) *Clear spaces.* Working space required by this subpart shall not be used for storage. When normally enclosed live parts are exposed for inspection or servicing, the working space, if in a passageway or general open space, shall be guarded.

(iii) *Access and entrance to working space.* At least one entrance shall be provided to give access to the working space about electric equipment.

(iv) *Front working space.* Where there are live parts normally exposed on the front of switchboards or motor control centers, the working space in front of such equipment shall not be less than 3 feet (914 mm).

(v) *Headroom.* The minimum headroom of working spaces about service equipment, switchboards, panelboards, or motor control centers shall be 6 feet 3 inches (1.91 m).

(2) *Guarding of live parts.* (i) Except as required or permitted elsewhere in this subpart, live parts of electric equipment operating at 50 volts or more shall be guarded against accidental contact by cabinets or other forms of enclosures, or by any of the following means:

(A) By location in a room, vault, or similar enclosure that is accessible only to qualified persons.

(B) By partitions or screens so arranged that only qualified persons will have access to the space within reach of the live parts. Any openings in such partitions or screens shall be so sized and located that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.

(C) By location on a balcony, gallery, or platform so elevated and arranged as to exclude unqualified persons.

(D) By elevation of 8 feet (2.44 m) or more above the floor or other working surface and so installed as to exclude unqualified persons.

(ii) In locations where electric equipment would be exposed to physical damage, enclosures or guards shall be so arranged and of such strength as to prevent such damage.

(iii) Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding unqualified persons to enter.

(j) *Over 600 volts, nominal.* (1) *General.* Conductors and equipment used on circuits exceeding 600 volts, nominal, shall comply with all applicable provisions of paragraphs (a) through (g) of this section and with the following provisions which supplement or modify those requirements. The provisions of paragraphs (j)(2), (j)(3), and (j)(4) of this section do not apply to equipment on the supply side of the service conductors

(2) *Enclosure for electrical installations.* Electrical installations in a vault, room, closet or in an area surrounded by a wall, screen, or fence, access to which is controlled by lock and key or other equivalent means, are considered to be accessible to qualified persons only. A wall, screen, or fence less than 8 feet (2.44 m) in height is not considered adequate to prevent access unless it has other features that provide a degree of isolation equivalent to an 8-foot (2.44 m) fence. The entrances to all buildings, rooms or enclosures containing exposed live parts or exposed conductors operating at over 600 volts, nominal, shall be kept locked or shall be under the observation of a qualified person at all times.

(i) *Installations accessible to qualified persons only.* Electrical installations having exposed live parts shall be accessible to qualified persons only and shall comply with the applicable provisions of paragraph (j)(3) of this section.

(ii) *Installations accessible to unqualified persons only.* Electrical installations that are open to unqualified persons shall be made with metal-enclosed equipment or shall be enclosed in a vault or in an area, access to which is controlled by a lock. Metal-enclosed switchgear, unit substations, transformers, pull boxes, connection boxes, and other similar associated equipment shall be marked with appropriate caution signs. If equipment is exposed to physical damage from vehicular traffic, guards shall be provided to prevent such damage. Ventilating or similar openings in metal-enclosed equipment shall be designed so that foreign objects inserted through these openings will be deflected from energized parts.

(3) *Workspace about equipment.* Sufficient space shall be provided and maintained about electric equipment to permit ready and safe operation and maintenance of such equipment. Where energized parts are exposed, the minimum clear workspace shall not be less than 6 feet 6 inches (1.98 m) high (measured vertically from the floor or platform), or less than 3 feet (914 mm). wide (measured parallel to the equipment). The depth shall be as required in Table K-2. The workspace shall be adequate to permit at least a 90-degree opening of doors or hinged panels.

Table K-2—Minimum Depth of Clear Working Space in Front of Electric Equipment

Nominal voltage to ground	Conditions[1]		
	(a)	(b)	(c)
	Feet[2]	Feet[2]	Feet[2]
601 to 2,500	3	4	5
2,501 to 9,000	4	5	6
9,001 to 25,000	5	6	9
25,001 to 75 kV	6	8	10
Above 75kV	8	10	12

[1] Conditions (a), (b), and (c) are as follows (a) Exposed live parts on one side and no live or grounded parts on the other side of the working space, or exposed live parts on both sides effectively guarded by insulating materials. Insulated wire or insulated busbars operating at not over 300 volts are not considered live parts.(b) Exposed live parts on one side and grounded parts on the other side. Walls constructed of concrete, brick, or tile are considered to be grounded surfaces. (c) Exposed live parts on both sides of the work-space [not guarded as provided in Condition (a)] with the operator between.

[2] Note:: For SI units: one foot=0.3048 m.

(i) *Working space.* The minimum clear working space in front of electric equipment such as switchboards, control panels, switches, circuit breakers, motor controllers, relays, and similar equipment shall not be less than specified in Table K-2 unless otherwise specified in this subpart. Distances shall be measured from the live parts if they are exposed, or from the enclosure front or opening if the live parts are enclosed. However, working space is not required in back of equipment such as deadfront switchboards or control assemblies where there are no renewable or adjustable parts (such as fuses or switches) on the back and where all connections are accessible from locations other than the back. Where rear access is required to work on de-energized parts on the back of enclosed equipment, a minimum working space of 30 inches (762 mm) horizontally shall be provided.

(ii) *Lighting outlets and points of control.* The lighting outlets shall be so arranged that persons changing lamps or making repairs on the lighting system will not be endangered by live parts or other equipment. The points of control shall be so located that persons are not likely to come in contact with any live part of moving part of the equipment while turning on the lights.

(iii) *Elevation of unguarded live parts.* Unguarded live parts above working space shall be maintained at elevations not less than specified in Table K-3.

Table K-3—Elevation of Unguarded Energized Parts Above Working Space

Nominal voltage between phases	Minimum elevation
601-7,500	8 feet 6 inches[1]
7,501-35,000	9 feet.
Over 35kV	9 feet +0.37 inches per kV above 35kV.

[1] Note: For SI units: one inch=25.4 mm; one foot =0.3048 m.

(4) *Entrance and access to workspace.* At least one entrance not less than 24 inches (610 mm) wide and 6 feet 6 inches (1.98 m) high shall be provided to give access to the working space about electric equipment. On switchboard and control panels exceeding 48 inches (1.22m) in width, there shall be one entrance at each end of such board where practicable. Where a bare energized parts at any voltage or insulated energized parts above 600 volts are located adjacent to such entrance, they shall be guarded.

(Information, collection requirements contained in paragraphs (g) and (b) were approved by the Office of Management and Budget under control number 1218 -0130)

§1926.404 Wiring design and protection.

(a) *Use and identification of grounded and grounding conductors*—(1) *Identification of conductors.* A conductor used as a grounded conductor shall be identifiable and distinguishable from all other conductors. A conductor used as an equipment grounding conductor shall be identifiable and distinguishable from all other conductors.

(2) *Polarity of connections.* No grounded conductor shall be attached to any terminal or lead so as to reverse designated polarity.

(3) *Use of grounding terminals and devices.* A grounding terminal or grounding-type device on a receptacle, cord connector, or attachment plug shall not be used for purposes other than grounding.

(b) *Branch circuits*—(1) *Ground-fault protection*—(i) *General.* The employer shall use either ground fault circuit interrupters as specified in paragraph (b)(1)(ii) of this section or an assured equipment grounding conductor program as specified in paragraph (b)(1)(iii) of this section to protect employees on construction sites. These requirements are in addition to any other requirements for equipment grounding conductors:

(ii) *Ground-fault circuit interrupters.* All 120-volt, single-phase, 15- and 20-ampere receptacle outlets on construction sites, which are not a part of the permanent wiring of the building or structure and which are in use by employees, shall have approved ground-fault circuit interrupters for personnel protection. Receptacles on a two-wire, single-phase portable or vehicle-mounted generator rated not more than 5kW, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces, need not be protected with ground-fault circuit interrupters.

(iii) *Assured equipment grounding conductor program.* The employer shall establish and implement an assured equipment grounding conductor program on construction sites covering all cord sets, receptacles which are not a part of the building or structure, and equipment connected by cord and plug which are available for use or used by employees. This program shall comply with the following minimum requirements:

(A) A written description of the program, including the specific procedures adopted by the employer, shall be available at the jobsite for inspection and copying by the Assistant Secretary and any affected employee.

(B) The employer shall designate one or more competent persons (as defined in §1926.32(f)) to implement the program.

(C) Each cord set, attachment cap, plug and receptacle of cord sets, and any equipment connected by cord and plug, except cord sets and receptacles which are fixed and not exposed to damage, shall be visually inspected before each day's use for external defects, such as deformed or missing pins or insulation damage, and for indications of possible internal damage. Equipment found damaged or defective shall not be used until repaired.

(D) The following tests shall be performed on all cord sets, receptacles which are not a part of the permanent wiring of the building or structure, and cord-and plug-connected equipment required to be grounded:

(*1*) All equipment grounding conductors shall be tested for continuity and shall be electrically continuous.

(*2*) Each receptacle and attachment cap or plug shall be tested for correct attachment of the equipment grounding conductor. The equipment grounding conductor shall be connected to its proper terminal.

(E) All required tests shall be performed:

(*1*) Before first use;

(*2*) Before equipment is returned to service following any repairs;

(*3*) Before equipment is used after any incident which can be reasonably suspected to have caused damage (for example, when a cord set is run over); and

(*4*) At intervals not to exceed 3 months, except that cord sets and receptacles which are fixed and not exposed to damage shall be tested at intervals not exceeding 6 months.

(F) The employer shall not make available or permit the use by employees of any equipment which has not met the requirements of this paragraph (b)(1)(iii) of this section.

(G) Tests performed as required in this paragraph shall be recorded. This test record shall identify each receptacle, cord set, and cord- and plug-connected equipment that passed the test and shall indicate the last date it was tested or the interval for which it was tested. This record shall be kept by means of logs, color coding, or other color coding, or other effective means and shall be maintained until replaced by a more current record. The record shall be made available on the jobsite for inspection by the Assistant Secretary and any affected employee.

(2) *Outlet devices.* Outlet devices shall have an ampere rating not less than the load to be served and shall comply with the following:

(i) *Single receptacles.* A single receptacle installed on an individual branch circuit shall have an ampere rating of not less than that of the branch circuit.

(ii) *Two or more receptacles.* Where connected to a branch circuit supplying two or more receptacles or outlets, receptacle ratings shall conform to the values listed in Table K-4.

Table K-4—Receptacle Ratings for Various Size Circuits

Circuit rating amperes	Receptacle rating amperes
15	Not over 15.
20	15 or 20.
30	30.
40	40 or 50.
50	50.

(iii) *Receptacles used for the connection of motors.* The rating of an attachment plug or receptacle used for cord- and plug-connection of a motor to a branch circuit shall not exceed 15 amperes at 125 volts or 10 amperes at 250 volts if individual overload protection is omitted.

(c) *Outside conductors and lamps*—(1) *600 volts, nominal, or less.* Paragraphs (c)(1)(i) through (c)(1)(iv) of this section apply to branch circuit, feeder, and service conductors rated 600 volts, nominal, or less and run outdoors as open conductors.

(i) *Conductors on poles.* Conductors supported on poles shall provide a horizontal climbing space not less than the following:

(A) Power conductors below communication conductors—30 inches (762 mm).

(B) Power conductors alone or above communication conductors: 300 volts or less—24 inches (610 mm): more than 300 volts—30 inches (762 mm).

(C) Communication conductors below power conductors: with power conductors 300 volts or less—24 inches (610 mm); more than 300 volts —30 inches (762 mm).

(ii) *Clearance from ground.* Open conductors shall conform to the following minimum clearances:

(A) 10 feet (3.05 m)—above finished grade, sidewalks, or from any platform or projection from which they might be reached.

(B) 12 feet (3.66 m)—over areas subject to vehicular traffic other than truck traffic.

(C) 15 feet (4.57 m)—over areas other than those specified in paragraph (c)(1)(ii)(D) of this section that are subject to truck traffic.

(D) 18 feet (5.49 m)—over public streets, alleys, roads, and driveways.

(iii) *Clearance from building openings.* Conductors shall have a clearance of at least 3 feet (914 mm) from windows, doors, fire escapes, or similar locations. Conductors run above the top level of a window are considered to be out of reach from that window and, therefore, do not have to be 3 feet (914 mm) away.

(iv) *Clearance over roofs.* Conductors above roof space accessible to employees on foot shall have a clearance from the highest point of the roof surface of not less than 8 feet (2.44 m) vertical clearance for insulated conductors, not less than 10 feet (3.05 m) vertical or diagonal clearance for covered conductors, and not less than 15 feet (4.57 m) for bare conductors, except that:

(A) Where the roof space is also accessible to vehicular traffic, the vertical clearance shall not be less than 18 feet (5.49 m), or

(B) Where the roof space is not normally accessible to employees on foot, fully insulated conductors shall have a vertical or diagonal clearance of not less than 3 feet (914 mm), or

(C) Where the voltage between conductors is 300 volts or less and the roof has a slope of not less than 4 inches (102 mm) in 12 inches (305 mm), the clearance from roofs shall be at least 3 feet (914 mm), or

(D) Where the voltage between conductors is 300 volts or less and the conductors do not pass over more than 4 feet (1.22 m) of the overhang portion of the roof and they are terminated at a through-the-roof raceway or support, the clearance from roofs shall be at least 18 inches (457 mm).

(2) *Location of outdoor lamps.* Lamps for outdoor lighting shall be located below all live conductors, transformers, or other electric equipment, unless such equipment is controlled by a disconnecting means that can be locked in the open position or unless adequate clearances or other safeguards are provided for relamping operations.

(d) *Services*—(1) *Disconnecting means*—(i) *General.* Means shall be provided to disconnect all conductors in a building or other structure from the service-entrance conductors. The disconnecting means shall plainly indicate whether it is in the open or closed position and shall be installed at a readily accessible location nearest the point of entrance of the service-entrance conductors.

(ii) *Simultaneous opening of poles.* Each service disconnecting means shall simultaneously disconnect all ungrounded conductors.

(2) *Services over 600 volts, nominal.* The following additional requirements apply to services over 600 volts, nominal.

(i) *Guarding.* Service-entrance conductors installed as open wires shall be guarded to make them accessible only to qualified persons.

(ii) *Warning signs.* Signs warning of high voltage shall be posted where unauthorized employees might come in contact with live parts.

(e) *Overcurrent protection*—(1) *600 volts, nominal, or less.* The following requirements apply to overcurrent protection of circuits rated 600 volts, nominal, or less.

(i) *Protection of conductors and equipment.* Conductors and equipment shall be protected from overcurrent in accordance with their ability to safely conduct current. Conductors shall have sufficient ampacity to carry the load.

(ii) *Grounded conductors.* Except for motor-running overload protection, overcurrent devices shall not interrupt the continuity of the grounded conductor unless all conductors of the circuit are opened simultaneously.

(iii) *Disconnection of fuses and thermal cutouts.* Except for devices provided for current-limiting on the supply side of the service disconnecting means, all cartridge fuses which are accessible to other than qualified persons and all fuses and thermal cutouts on circuits over 150 volts to ground shall be provided with disconnecting means. This disconnecting means shall be installed so that the fuse or thermal cutout can be disconnected from its supply without disrupting service to equipment and circuits unrelated to those protected by the overcurrent device.

(iv) *Location in or on premises.* Overcurrent devices shall be readily accesible. Overcurrent device shall not be located where they could create an employee safety hazard by being exposed to physical damage or located in the vicinity of easily ignitible material.

(v) *Arcing or suddenly moving parts.* Fuses and circuit breakers shall be so located or shielded that employees will not be burned or otherwise injured by their operation.

(vi) *Circuit breakers*—(A) Circuit breakers shall clearly indicate whether they are in the open (off) or closed (on) position.

(B) Where circuit breaker handles on switchboards are operated vertically rather than horizontally or rotationally, the up position of the handle shall be the closed (on) position.

(C) If used as switches in 120-volt, fluorescent lighting circuits, circuit breakers shall be marked SWD."

(2) *Over 600 volts, nominal.* Feeders and branch circuits over 600 volts, nominal, shall have short-circuit protection.

(f) *Grounding.* Paragraphs (f)(1) through (f)(11) of this section contain grounding requirements for systems, circuits, and equipment.

(1) *Systems to be grounded.* The following systems which supply premises wiring shall be grounded:

(i) *Three-wire DC systems.* All 3-wire DC systems shall have their neutral conductor grounded.

(ii) *Two-wire DC systems.* Two-wire DC systems operating at over 50 volts through 300 volts between conductors shall be grounded unless they are rectifier-derived from an AC system complying with paragraphs (f)(1)(iii), (f)(1)(iv), and (f)(1)(v) of this section.

(iii) *AC circuits, less than 50 volts.* AC circuits of less than 50 volts shall be grounded if they are installed as overhead conductors outside of buildings or if they are supplied by transformers and the transformer primary supply system is ungrounded or exceeds 150 volts to ground.

(iv) *AC systems, 50 volts to 1000 volts.* AC systems of 50 volts to 1000 volts shall be grounded under any of the following conditions, unless exempted by paragraph (f)(1)(v) of this section:

(A) If the system can be so grounded that the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts;

(B) If the system is nominally rated 480Y/277 volt, 3-phase, 4-wire in which the neutral is used as a circuit conductor;

(C) If the system is nominally rated 240/120 volt, 3-phase, 4-wire in which the midpoint of one phase is used as a circuit conductor; or

(D) If a service conductor is uninsulated.

(v) *Exceptions.* AC systems of 50 volts to 1000 volts are not required to be grounded if the system is separately derived and is supplied by a transformer that has a primary voltage rating less than 1000 volts, provided all of the following conditions are met:

(A) The system is used exclusively for control circuits,

(B) The conditions of maintenance and supervision assure that only qualified persons will service the installation,

(C) Continuity of control power is required, and

(D) Ground detectors are installed on the control system.

(2) *Separately derived systems.* Where paragraph (f)(1) of this section requires grounding of wiring systems whose power is derived from generator, transformer, or converter windings and has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system, paragraph (f)(5) of this section shall also apply.

(3) *Portable and vehicle-mounted generators*—(i) *Portable generators.* Under the following conditions, the frame of a portable generator need not be grounded and may serve as the grounding electrode for a system supplied by the generator:

(A) The generator supplies only equipment mounted on the generator and/or cord-and plug-connected equipment through receptacles mounted on the generator, and

(B) The noncurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame.

(ii) *Vehicle-mounted generators.* Under the following conditions the frame of a vehicle may serve as the grounding electrode for a system supplied by a generator located on the vehicle:

(A) The frame of the generator is bonded to the vehicle frame, and

(B) The generator supplies only equipment located on the vehicle and/or cord-and plug-connected equipment through receptacles mounted on the vehicle or on the generator, and

(C) The noncurrent-carrying metal parts of equipment and the equipment grounding conductor terminals of the receptacles are bonded to the generator frame, and

(D) The system complies with all other provisions of this section.

(iii) *Neutral conductor bonding.* A neutral conductor shall be bonded to the generator frame if the generator is a component of a separately derived system. No other conductor need be bonded to the generator frame.

(4) *Conductors to be grounded.* For AC premises wiring systems the identified conductor shall be grounded.

(5) *Grounding connection*—(i) *Grounded system.* For a grounded system, a grounding electrode conductor shall be used to connect both the equipment grounding conductor and the grounded circuit conductor to the grounding elec-

trode. Both the equipment grounding conductor and the grounding electrode conductor shall be connected to the grounded circuit conductor on the supply side of the service disconnecting means, or on the supply side of the system disconnecting means or overcurrent devices if the system is separately derived.

(ii) *Ungrounded systems.* For an ungrounded service-supplied system, the equipment grounding conductor shall be connected to the grounding electrode conductor at the service equipment. For an ungrounded separately derived system, the equipment grounding conductor shall be connected to the grounding electrode conductor at, or ahead of, the system disconnecting means or overcurrent devices.

(6) *Grounding path.* The path to ground from circuits, equipment, and enclosures shall be permanent and continuous.

(7) *Supports, enclosures, and equipment to be grounded*—(i) *Supports and enclosures for conductors.* Metal cable trays, metal raceways, and metal enclosures for conductors shall be grounded, except that:

(A) Metal enclosures such as sleeves that are used to protect cable assemblies from physical damage need not be grounded; and

(B) Metal enclosures for conductors added to existing installations of open wire, knob-and-tube wiring, and nonmetallic-sheathed cable need not be grounded if all of the following conditions are met:

(*1*) Runs are less than 25 feet (7.62m);

(*2*) Enclosures are free from probable contact with ground, grounded metal, metal laths, or other conductive materials; and

(*3*) Enclosures are guarded against employee contact.

(ii) *Service equipment, enclosures.* Metal enclosures for service equipment shall be grounded.

(iii) *Fixed equipment.* Exposed noncurrent-carrying metal parts of fixed equipment which may become energized shall be grounded under any of the following conditions:

(A) If within 8 feet (2.44m) vertically or 5 feet (1.52m) horizontally of ground or grounded metal objects and subject to employee contact.

(B) If located in a wet or damp location and subject to employee contact.

(C) If in electrical contact with metal.

(D) If in a hazardous (classified) location.

(E) If supplied by a metal-clad, metal-sheathed, or grounded metal raceway wiring method.

(F) If equipment operates with any terminal at over 150 volts to ground; however, the following need not be grounded:

(*1*) Enclosures for switches or circuit breakers used for other than service equipment and accessible to qualified persons only;

(*2*) Metal frames of electrically heated appliances which are permanently and effectively insulated from ground; and

(*3*) The cases of distribution apparatus such as transformers and capacitors mounted on wooden poles at a height exceeding 8 feet (2.44m) above ground or grade level.

(iv) *Equipment connected by cord and plug.* Under any of the conditions described in paragraphs (f)(7)(iv)(A) through (f)(7)(iv)(C) of this section, exposed noncurrent-carrying metal parts of cord-and plug-connected equipment which may become energized shall be grounded:

(A) If in a hazardous (classified) location (see §1926.407).

(B) If operated at over 150 volts to ground, except for guarded motors and metal frames of electrically heated appliances if the appliance frames are permanently and effectively insulated from ground.

(C) If the equipment is one of the types listed in paragraphs (f)(7)(iv)(C)(1) through (f)(7)(iv)(C)(5) of this section. However, even though the equipment may be one of these types, it need not be grounded if it is exempted by paragraph (f)(7)(iv)(C)(6).

(*1*) Hand held motor-operated tools;

(*2*) Cord-and plug-connected equipment used in damp or wet locations or by employees standing on the ground or on metal floors or working inside of metal tanks or boilers;

(*3*) Portable and mobile X-ray and associated equipment;

(*4*) Tools likely to be used in wet and/or conductive locations; and

(*5*) Portable hand lamps.

(*6*) Tools likely to be used in wet and/or conductive locations need not be grounded if supplied through an isolating transformer with an ungrounded secondary of not over 50 volts. Listed or labeled portable tools and appliances protected by a system of double insulation, or its equivalent, need not be grounded. If such a system is employed, the equipment shall be distinctively marked to indicate that the tool or appliance utilizes a system of double insulation.

(v) *Nonelectrical equipment.* The metal parts of the following nonelectrical equipment shall be grounded: Frames and tracks of electrically operated cranes; frames of nonelectrical driven elevator cars to which electric conductors are attached; hand-operated metal shifting ropes or cables of electric elevators, and metal partitions, grill work, and similar metal enclosures around equipment of over IkV between conductors.

(8) *Methods of grounding equipment*—(i) *With circuit conductors.* Noncurrent-carrying metal parts of fixed equipment, if required to be grounded by this subpart, shall be grounded by an equipment grounding conductor which is contained within the same raceway, cable, or cord, or runs with or encloses the circuit conductors. For DC circuits only, the equipment grounding conductor may be run separately from the circuit conductors.

(ii) *Grounding conductor.* A conductor used for grounding fixed or movable equipment shall have capacity to conduct safely any fault current which may be imposed on it.

(iii) *Equipment considered effectively grounded.* Electric equipment is considered to be effectively grounded if it is secured to, and in electrical contact with, a metal rack or structure that is provided for its support and the metal rack or structure is grounded by the method specified for the noncurrent-carrying metal parts of fixed equipment in paragraph (f)(8)(i) of this section. Metal car frames supported by metal hoisting cables attached to or running over metal sheaves or drums of grounded elevator machines are also considered to be effectively grounded.

(9) *Bonding.* If bonding conductors are used to assure electrical continuity, they shall have the capacity to conduct any fault current which may be imposed.

(10) *Made electrodes.* If made electrodes are used, they shall be free from nonconductive coatings, such as paint or enamel; and, if practicable, they shall be embedded below permanent moisture level. A single electrode consisting of a rod, pipe or plate which has a resistance to ground greater than 25 ohms shall be augmented by one additional electrode installed no closer than 6 feet (1.83 m) to the first electrode.

(11) *Grounding of systems and circuits of 1000 volts and over (high voltage)*—(i) *General.* If high voltage systems are grounded, they shall comply with all applicable provisions of paragraphs (f)(1) through (f)(10) of this section as supplemented and modified by this paragraph (f)(11).

(ii) *Grounding of systems supplying portable or mobile equipment.* Systems supplying portable or mobile high voltage equipment, other than substations installed on a temporary basis, shall comply with the following:

(A) Portable and mobile high voltage equipment shall be supplied from a system having its neutral grounded through an impedance. If a delta-connected high voltage system is used to supply the equipment, a system neutral shall be derived.

(B) Exposed noncurrent-carrying metal parts of portable and mobile equipment shall be connected by an equipment grounding conductor to the point at which the system neutral impedance is grounded.

(C) Ground-fault detection and relaying shall be provided to automatically de-energize any high voltage system component which has developed a ground fault. The continuity of the equipment grounding conductor shall be continuously monitored so as to de-energize automatically the high voltage feeder to the portable equipment upon loss of continuity of the equipment grounding conductor.

(D) The grounding electrode to which the portable or mobile equipment system neutral impedance is connected shall be isolated from and separated in the ground by at least 20 feet (6.1 m) from any other system or equipment grounding electrode, and there shall be no direct connection between the grounding electrodes, such as buried pipe, fence or like objects.

(iii) *Grounding of equipment.* All noncurrent-carrying metal parts of portable equipment and fixed equipment including their associated fences, housings, enclosures, and supporting structures shall be grounded. However, equipment which is guarded by location and isolated from ground need not be grounded. Additionally pole-mounted distribution apparatus at a height exceeding 8 feet (2.44 m) above ground or grade level need not be grounded.

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§1926.405 Wiring methods, components, and equipment for general use.

(a) *Wiring methods.* The provisions of this paragraph do not apply to conductors which form an integral part of equipment such as motors, controllers, motor control centers and like equipment.

(1) *General requirements*—(i) *Electrical continuity of metal raceways and enclosures.* Metal raceways, cable armor, and other metal enclosures for conductors shall be metallically joined together into a continuous electric conductor and shall be so connected to all boxes, fittings, and cabinets as to provide effective electrical continuity.

(ii) *Wiring in ducts.* No wiring systems of any type shall be installed in ducts used to transport dust, loose stock or flammable vapors. No wiring system of any type shall be installed in any duct used for vapor removal or in any shaft containing only such ducts.

(2) *Temporary wiring*—(i) *Scope.* The provisions of paragraph (a)(2) of this section apply to temporary electrical power and lighting wiring methods which may be of a class less than would be required for a permanent installation. Except as specifically modified in paragraph (a)(2) of this section, all other requirements of this subpart for permanent wiring shall apply to temporary wiring installations. Temporary wiring shall be removed immediately upon completion of construction or the purpose for which the wiring was installed.

(ii) *General requirements for temporary wiring.*—(A) Feeders shall originate in a distribution center. The conductors shall be run as multiconductor cord or cable assemblies or within raceways; or, where not subject to physical damage, they may be run as open conductors on insulators not more than 10 feet (3.05 m) apart.

(B) Branch circuits shall originate in a power outlet or panelboard. Conductors shall be run as multiconductor cord or cable assemblies or open conductors, or shall be run in raceways. All conductors shall be protected by overcurrent devices at their ampacity. Runs of open conductors shall be located where the conductors will not be subject to physical damage, and the conductors shall be fastened at intervals not exceeding 10 feet (3.05 m). No branch-circuit conductors shall be laid on the floor. Each branch circuit that supplies receptacles or fixed equipment shall contain a separate equipment grounding conductor if the branch circuit is run as open conductors.

(C) Receptacles shall be of the grounding type. Unless installed in a complete metallic raceway, each branch circuit shall contain a separate equipment grounding conductor, and all receptacles shall be electrically connected to the grounding conductor. Receptacles for uses other than temporary lighting shall not be installed on branch circuits which supply temporary lighting. Receptacles shall not be connected to the same ungrounded conductor of multiwire circuits which supply temporary lighting.

(D) Disconnecting switches or plug connectors shall be installed to permit the disconnection of all ungrounded conductors of each temporary circuit.

(E) All lamps for general illumination shall be protected from accidental contact or breakage. Metal-case sockets shall be grounded.

(F) Temporary lights shall not be suspended by their electric cords unless cords and lights are designed for this means of suspension.

(G) Portable electric lighting used in wet and/or other conductive locations as for example, drums, tanks, and vessels, shall be operated at 12 volts or less. However, 120-volt lights may be used if protected by a ground-fault circuit interrupter.

(H) A box shall be used wherever a change is made to a raceway system or a cable system which is metal clad or metal sheathed.

(I) Flexible cords and cables shall be protected from damage. Sharp corners and projections shall be avoided. Flexible cords and cables may pass through doorways or other pinch points, if protection is provided to avoid damage.

(J) Extension cord sets used with portable electric tools and appliances shall be of three-wire type and shall be designed for hard or extra-hard usage. Flexible cords used with temporary and portable lights shall be designed for hard or extra-hard usage.

Note: The National Electrical Code, ANSI/NFPA 70, in Article 400, Table 400-4, lists various types of flexible cords, some of which are noted as being designed for hard or extra-hard usage. Examples of these types of flexible cords include hard service cord (types S, ST, SO, STO) and junior hard service cord (types SJ, SJO, SJT, SJTO).

(iii) *Guarding.* For temporary wiring over 600 volts, nominal, fencing, barriers, or other effective means shall be provided to prevent access of other than authorized and qualified personnel.

(b) *Cabinets, boxes, and fittings.* (1) *Conductors entering boxes, cabinets, or fittings.* Conductors entering boxes, cabinets, or fittings shall be protected from abrasion, and openings through which conductors enter shall be effectively closed. Unused openings in cabinets, boxes, and fittings shall also be effectively closed.

(2) *Covers and canopies.* All pull boxes, junction boxes, and fittings shall be provided with covers. If metal covers are used, they shall be grounded. In energized installations each outlet box shall have a cover, faceplate, or fixture canopy. Covers of outlet boxes having holes through which flexible cord pendants pass shall be provided with bushings designed for the purpose or shall have smooth, well-rounded surfaces on which the cords may bear.

(3) *Pull and junction boxes for systems over 600 volts, nominal.* In addition to other requirements in this section for pull and junction boxes, the following shall apply to these boxes for systems over 600 volts, nominal:

(i) *Complete enclosure.* Boxes shall provide a complete enclosure for the contained conductors or cables.

(ii) *Covers.* Boxes shall be closed by covers securely fastened in place. Underground box covers that weigh over 100 pounds (43.6 kg) meet this requirement. Covers for boxes shall be permanently marked "HIGH VOLTAGE." The marking shall be on the outside of the box cover and shall be readily visible and legible.

(c) *Knife switches.* Single-throw knife switches shall be so connected that the blades are dead when the switch is in the open position. Single-throw knife switches shall be so placed that gravity will not tend to close them. Single-throw knife switches approved for use in the inverted position shall be provided with a locking device that will ensure that the blades remain in the open position when so set. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal. However, if the throw is vertical, a locking device shall be provided to ensure that the blades remain in the open position when so set.

(d) *Switchboards and panelboards.* Switchboards that have any exposed live parts shall be located in permanently dry locations and accessible only to qualified persons. Panelboards shall be mounted in cabinets, cutout boxes, or enclosures designed for the purpose and shall be dead front. However, panelboards other than the dead front externally-operable type are permitted where accessible only to qualified persons. Exposed blades of knife switches shall be dead when open.

(e) *Enclosures for damp or wet locations.* (1) *Cabinets, fittings, and boxes.* Cabinets, cutout boxes, fittings, boxes, and panelboard enclosures in damp or wet locations shall be installed so as to prevent moisture or water from entering and accumulating within the enclosures. In wet locations the enclosures shall be weatherproof.

(2) *Switches and circuit breakers.* Switches, circuit breakers, and switchboards installed in wet locations shall be enclosed in weatherproof enclosures.

(f) *Conductors for general wiring.* All conductors used for general wiring shall be insulated unless otherwise permitted in this Subpart. The conductor insulation shall be of a type that is suitable for the voltage, operating temperature, and location of use. Insulated conductors shall be distinguishable by appropriate color or other means as being grounded conductors, ungrounded conductors, or equipment grounding conductors.

(g) *Flexible cords and cables*—(1) *Use of flexible cords and cables*—(i) *Permitted uses.* Flexible cords and cables shall be suitable for conditions of use and location. Flexible cords and cables shall be used only for:

(A) Pendants;

(B) Wiring of fixtures;

(C) Connection of portable lamps or appliances;

(D) Elevator cables;

(E) Wiring of cranes and hoists;

(F) Connection of stationary equipment to facilitate their frequent interchange;

(G) Prevention of the transmission of noise or vibration; or

(H) Appliances where the fastening means and mechanical connections are designed to permit removal for maintenance and repair.

(ii) *Attachment plugs for cords.* If used as permitted in paragraphs (g)(1)(i)(C), (g)(1)(i)(F), or (g)(1)(i)(H) of this section, the flexible cord shall be equipped with an attachment plug and shall be energized from a receptacle outlet.

(iii) *Prohibited uses.* Unless necessary for a use permitted in paragraph (g)(1)(i) of this section, flexible cords and cables shall not be used:

(A) As a substitute for the fixed wiring of a structure;

(B) Where run through holes in walls, ceilings, or floors;

(C) Where run through doorways, windows, or similar openings, except as permitted in paragraph (a)(2)(ii)(1) of this section;

(D) Where attached to building surfaces; or

(E) Where concealed behind building walls, ceilings, or floors.

(2) *Identification, splices, and terminations*—(i) *Identification.* A conductor of a flexible cord or cable that is used as a grounded conductor or an equipment grounding conductor shall be distinguishable from other conductors.

(ii) *Marking.* Type SJ, SJO, SJT, SJTO, S, SO, ST, and STO cords shall not be used unless durably marked on the surface with the type designation, size, and number of conductors.

(iii) *Splices.* Flexible cords shall be used only in continuous lengths without splice or tap. Hard service flexible cords No. 12 or larger may be repaired if spliced so that the splice retains the insulation, outer sheath properties, and usage characteristics of the cord being spliced.

(iv) *Strain relief.* Flexible cords shall be connected to devices and fittings so that strain relief is provided which will prevent pull from being directly transmitted to joints or terminal screws.

(v) *Cords passing through holes.* Flexible cords and cables shall be protected by bushings or fittings where passing through holes in covers, outlet boxes, or similar enclosures.

(h) *Portable cables over 600 volts, nominal.* Multiconductor portable cable for use in supplying power to portable or mobile equipment at over 600 volts, nominal, shall consist of No. 8 or larger conductors employing flexible stranding. Cables operated at over 2000 volts shall be shielded for the purpose of confining the voltage stresses to the insulation. Grounding conductors shall be provided. Connectors for these cables shall be of a locking type with provisions to prevent their opening or closing while energized. Strain relief shall be provided at connections and terminations. Portable cables shall not be operated with splices unless the splices are of the permanent molded, vulcanized, or other equivalent type. Termination enclosures shall be marked with a high voltage hazard warning, and terminations shall be accessible only to authorized and qualified personnel.

(i) *Fixture wires*—(1) *General.* Fixture wires shall be suitable for the voltage, temperature, and location of use. A fixture wire which is used as a grounded conductor shall be identified.

(2) *Uses permitted.* Fixture wires may be used:

(i) For installation in lighting, fixtures and in similar equipment where enclosed or protected and not subject to bending or twisting in use; or

(ii) For connecting lighting fixtures to the branch-circuit conductors supplying the fixtures.

(3) *Uses not permitted.* Fixture wires shall not be used as branch-circuit conductors except as permitted for Class 1 power-limited circuits.

(j) *Equipment for general use*—(1) *Lighting fixtures, lampholders, lamps, and receptacles*—(i) *Live parts.* Fixtures, lampholders, lamps, rosettes, and receptacles shall have no live parts normally exposed to employee contact. However, rosettes and cleat-type lampholders and receptacles located at least 8 feet (2.44 m) above the floor may have exposed parts.

(ii) *Support.* Fixtures, lampholders, rosettes, and receptacles shall be securely supported. A fixture that weighs more than 6 pounds (2.72 kg) or exceeds 16 inches (406 mm) in any dimension shall not be supported by the screw shell of a lampholder.

(iii) *Portable lamps.* Portable lamps shall be wired with flexible cord and an attachment plug of the polarized or grounding type. If the portable lamp uses an Edison-based lampholder, the grounded conductor shall be identified and attached to the screw shell and the identified blade of the attachment plug. In addition, portable handlamps shall comply with the following:

(A) Metal shell, paperlined lampholders shall not be used;

(B) Handlamps shall be equipped with a handle of molded composition or other insulating material;

(C) Handlamps shall be equipped with a substantial guard attached to the lampholder or handle;

(D) Metallic guards shall be grounded by the means of an equipment grounding conductor run within the power supply cord.

(iv) *Lampholders.* Lampholders of the screw-shell type shall be installed for use as lampholders only. Lampholders installed in wet or damp locations shall be of the weatherproof type.

(v) *Fixtures.* Fixtures installment in wet or damp locations shall be identified for the purpose and shall be installed so that water cannot enter or accumulate in wireways, lampholders, or other electrical parts.

(2) *Receptacles cord connectors and attachment plugs (caps)*—(i) *Configuration.* Receptacles, cord connectors, and attachment plugs shall be constructed so that no receptacle or cord connector will accept an attachment plug with a differ-

ent voltage or current rating than that for which the device is intended. However, a 20-ampere T-slot receptacle or cord connector may accept a 15-ampere attachment plug of the same voltage rating. Receptacles connected to circuits having different voltages, frequencies, or types of current (ac or dc) on the same premises shall be of such design that the attachment plugs used on these circuits, are not interchangeable.

(ii) *Damp and wet locations.* A receptacle installed in a wet or damp location shall be designed for the location.

(3) *Appliances*—(i) *Live parts.* Appliances, other than those in which the current-carrying parts at high temperatures are necessarily exposed, shall have no live parts normally exposed to employee contact.

(ii) *Disconnecting means.* A means shall be provided to disconnect each appliance.

(iii) *Rating.* Each appliance shall be marked with its rating in volts and amperes or volts and watts.

(4) *Motors.* This paragraph applies to motors, motor circuits, and controllers.

(i) *In sight from.* If specified that one piece of equipment shall be "in sight from" another piece of equipment, one shall be visible and not more than 50 feet (15.2 m) from the other.

(ii) *Disconnecting means*—(A) A disconnecting means shall be located in sight from the controller location. The controller disconnecting means for motor branch circuits over 600 volts, nominal, may be out of sight of the controller, if the controller is marked with a warning label giving the location and identification of the disconnecting means which is to be locked in the open position.

(B) The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors and shall be so designed that no pole can be operated independently.

(C) If a motor and the driven machinery are not in sight from the controller location, the installation shall comply with one of the following conditions:

(*1*) The controller disconnecting means shall be capable of being locked in the open position.

(*2*) A manually operable switch that will disconnect the motor from its source of supply shall be placed in sight from the motor location.

(D) The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position.

(E) The disconnecting means shall be readily accessible. If more than one disconnect is provided for the same equipment, only one need be readily accessible.

(F) An individual disconnecting means shall be provided for each motor, but a single disconnecting means may be used for a group of motors under any one of the following conditions.

(*1*) If a number of motors drive special parts of a single machine or piece of apparatus, such as a metal or woodworking machine, crane, or hoist;

(*2*) If a group of motors is under the protection of one set of branch-circuit protective devices; or

(*3*) If a group of motors is in a single room in sight from the location of the disconnecting means.

(iii) *Motor overload, short-circuit, and ground-fault protection.* Motors, motor-control apparatus, and motor branch-circuit conductors shall be protected against overheating due to motor overloads or failure to start,and against short-circuits or ground faults. These provisions do not require overload protection that will stop a motor where a shutdown is likely to introduce additional or increased hazards, as in the case of fire pumps, or where continued operation of a motor is necessary for a safe shutdown of equipment or process and motor overload sensing devices are connected to a supervised alarm.

(iv) *Protection of live parts—all voltages*—(A) Stationary motors having commutators, collectors, and brush rigging located inside of motor end brackets and not conductively connected to supply circuits operating at more than 150 volts to ground need not have such parts guarded. Exposed live parts of motors and controllers operating at 50 volts or more between terminals shall be guarded against accidental contact by any of the following:

(*1*) By installation in a room or enclosure that is accessible only to qualified persons;

(*2*) By installation on a balcony, gallery, or platform, so elevated and arranged as to exclude unqualified persons; or

(*3*) By elevation 8 feet (2.44 m) or more above the floor.

(B) Where live parts of motors or controllers operating at over 150 volts to ground are guarded against accidental contact only by location, and where adjustment or other attendance may be necessary during the operation of the apparatus, insulating mats or platforms shall be provided so that the attendant cannot readily touch live parts unless standing on the mats or platforms.

(5) *Transformers*—(i) *Application.* The following paragraphs cover the installation of all transformers, except:

(A) Current transformers;

(B) Dry-type transformers installed as a component part of other apparatus:

(C) Transformers which are an integral part of an X-ray, high frequency, or electrostatic-coating apparatus;

(D) Transformers used with Class 2 and Class 3 circuits, sign and outline lighting, electric discharge lighting, and power-limited fire-protective signaling circuits.

(ii) *Operating voltage.* The operating voltage of exposed live parts of transformer installations shall be indicated by warning signs or visible markings on the equipment or structure.

(iii) *Transformers over 35 kV.* Dry-type, high fire point liquid-insulated, and askarel-insulated transformers installed indoors and rated over 35 kV shall be in a vault.

(iv) *Oil-insulated transformers.* If they present a fire hazard to employees, oil-insulated transformers installed indoors shall be in a vault.

(v) *Fire protection.* Combustible material, combustible buildings and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires which may originate in oil-insulated transformers attached to or adjacent to a building or combustible material.

(vi) *Transformer vaults.* Transformer vaults shall be constructed so as to contain fire and combustible liquids within the vault and to prevent unauthorized access. Locks and latches shall be so arranged that a vault door can be readily opened from the inside.

(vii) *Pipes and ducts.* Any pipe or duct system foreign to the vault installation shall not enter or pass through a transformer vault.

(viii) *Material storage.* Materials shall not be stored in transformer vaults.

(6) *Capacitors*—(i) *Drainage of stored charge.* All capacitors, except surge capacitors or capacitors included as a component part of other apparatus, shall be provided with an automatic means of draining the stored charge and maintaining the discharged state after the capacitor is disconnected from its source of supply.

(ii) *Over 600 volts.* Capacitors rated over 600 volts, nominal, shall comply with the following additional requirements:

(A) Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load interrupting device or shall be provided with prominently displayed caution signs to prevent switching load current.

(B) For series capacitors the proper switching shall be assured by use of at least one of the following:

(*1*) Mechanically sequenced isolating and bypass switches,

(*2*) Interlocks, or

(*3*) Switching procedure prominently displayed at the switching location.

(Information collection requirements contained in paragraphs (g)(2)(ii), (j)(3)(iii), (j)(4)(ii)(A), (j)(5)(ii), and (j)(6)(ii)(B)(3) were approved by the Office of Management and Budget under control number 1218-0130)

§1926.406 Specific purpose equipment and installations.

(a) *Cranes and hoists.* This paragraph applies to the installation of electric equipment and wiring used in connection with cranes, monorail hoists, hoists, and all runways.

(1) *Disconnecting means*—(i) *Runway conductor disconnecting means.* A readily accessible disconnecting means shall be provided between the runway contact conductors and the power supply.

(ii) *Disconnecting means for cranes and monorail hoists.* A disconnecting means, capable of being locked in the open position, shall be provided in the leads from the runway contact conductors or other power supply on any crane or monorail hoist.

(A) If this additional disconnecting means is not readily accessible from the crane or monorail hoist operating station, means shall be provided at the operating station to open the power circuit to all motors of the crane or monorail hoist.

(B) The additional disconnect may be omitted if a monorail hoist or hand-propelled crane bridge installation meets all of the following:.

(*1*) The unit is floor controlled;

(*2*) The unit is within view of the power supply disconnecting means; and

(*3*) No fixed work platform has been provided for servicing the unit.

(2) *Control.* A limit switch or other device shall be provided to prevent the load block from passing the safe upper limit of travel of any hoisting mechanism.

(3) *Clearance.* The dimension of the working space in the direction of access to live parts which may require examination, adjustment, servicing, or maintenance while alive shall be a minimum of 2 feet 6 inches (762 mm). Where controls are enclosed in cabinets, the door(s) shall open at least 90 degrees or be removable, or the installation shall provide equivalent access.

(4) *Grounding.* All exposed metal parts of cranes, monorail hoists, hoists and accessories including pendant controls shall be metallically joined together into a continuous electrical conductor so that the entire crane or hoist will be grounded in accordance with §1926.404(f). Moving parts, other than removable accessories or attachments, having metal-to-metal bearing surfaces shall be considered to be electrically connected to each other through the bearing surfaces for grounding purposes. The trolley frame and bridge frame shall be considered as electrically grounded through the bridge and trolley wheels and its respective tracks unless conditions such as paint or other insulating materials prevent reliable metal-to-metal contact. In this case a separate bonding conductor shall be provided.

(b) *Elevators, escalators, and moving walks*—(1) *Disconnecting means.* Elevators, escalators, and moving walks shall have a single means for disconnecting all ungrounded main power supply conductors for each unit.

(2) *Control panels.* If control panels are not located in the same space as the drive machine, they shall be located in cabinets with doors or panels capable of being locked closed.

(c) *Electric welders—disconnecting means*—(1) *Motor-generator, AC transformer, and DC rectifier arc welders.* A disconnecting means shall be provided in the supply circuit for each motor-generator arc welder, and for each AC transformer and DC rectifier arc welder which is not equipped with a disconnect mounted as a integral part of the welder.

(2) *Resistance welders.* A switch or circuit breaker shall be provided by which each resistance welder and its control equipment can be isolated from the supply circuit. The ampere rating of this disconnecting means shall not be less than the supply conductor ampacity.

(d) *X-Ray equipment*—(1) *Disconnecting means*—(i) *General.* A disconnecting means shall be provided in the supply circuit. The disconnecting means shall be operable from a location readily accessible from the X-ray control. For equipment connected to a 120-volt branch circuit of 30 amperes or less, a grounding-type attachment plug cap and receptacle of proper rating may serve as a disconnecting means.

(ii) *More than one piece of equipment.* If more than one piece of equipment is operated from the same high-voltage circuit, each piece or each group of equipment as a unit shall be provided with a high-voltage switch or equivalent disconnecting means. This disconnecting means shall be constructed, enclosed, or located so as to avoid contact by employees with its live parts.

(2) *Control—Radiographic and fluoroscopic types.* Radiographic and fluoroscopic-type equipment shall be effectively enclosed or shall have interlocks that deenergize the equipment automatically to prevent ready access to have current-carrying parts.

§1926.407 Hazardous (classified) locations.

(a) *Scope.* This section sets forth requirements for electric equipment and wiring in locations which are classified depending on the properties of the flammable vapors, liquids or gases, or combustible dusts or fibers which may be present therein and the likelihood that a flammable or combustible concentration or quantity is present. Each room, section or area shall be considered individually in determining is classification. These hazardous (classified) locations are assigned six designations as follows:

Class I, Division 1
Class I, Division 2
Class II, Division 1
Class II, Division 2
Class III, Division 1
Class III, Division 2

For definitions of these locations see 1926.449. All applicable requirements in this subpart apply to all hazardous (classified) locations, unless modified by provisions of this section.

(b) *Electrical installations.* Equipment, wiring methods, and installations of equipment in hazardous (classified) locations shall be approved as intrinsically safe or approved for the hazardous (classified) location or safe for the hazardous (classified) location. Requirements for each of these options are as follows:

(1) *Intrinsically safe.* Equipment and associated wiring approved as intrinsically safe is permitted in any hazardous (classified) location included in its listing or labeling.

(2) *Approved for the hazardous (classified) location*—(i) *General.* Equipment shall be approved not only for the class of location but also for the ignitible or combustible properties of the specific gas, vapor, dust, or fiber that will be present.

Note: NFPA 70, the National Electrical Code, lists or defines hazardous gases, vapors, and dusts by Groups" characterized by their ignitible or combustible properties.

(ii) *Marking.* Equipment shall not be used unless it is marked to show the class, group, and operating temperature or temperature range, based on operation in a 40-degree C ambient, for which it is approved. The temperature marking shall not exceed the ignition temperature of the specific gas, vapor, or dust to be encountered. However, the following provisions modify this marking requirement for specific equipment.

(A) Equipment of the non-heat-producing type (such as junction boxes, conduit, and fitting) and equipment of the heat-producing type having a maximum temperature of not more than 100 degrees C (212 degrees F) need not have a marked operating temperature or temperature range.

(B) Fixed lighting fixtures marked for use only in Class I, Division 2 locations need not be marked to indicate the group.

(C) Fixed general-purpose equipment in Class I locations, other than lighting fixtures, which is acceptable for use in Class I, Division 2 locations need not be marked with the class, group, division, or operating temperature.

(D) Fixed dust-tight equipment, other than lighting fixtures, which is acceptable for use in Class II, Division 2 and Class III locations need not be marked with the class, group, division, or operating temperature.

(3) *Safe for the hazardous (classified) location.* Equipment which is safe for the location shall be of a type and design which the employer demonstrates will provide protection from the hazards from the hazards arising from the combustibili-

ty and flammability of vapors, liquids, gases, dusts, or fibers.

Note: The National Electrical Code, NFPA 70, contains guidelines for determining the type and design of equipment and installations which will meet this requirement. The guidelines of this document address electric wiring, equipment, and systems installed in hazardous (classified) locations and contain specific provisions for the following: wiring methods, wiring connections, conductor insulation, flexible cords, sealing and drainage, transformers, capacitors, switches, circuit breakers, fuses, motor controllers, receptacles, attachment plugs, meters, relays, instruments, resistors, generators, motors, lighting fixtures, storage battery charging equipment, electric cranes, electric hoists and similar equipment, utilization equipment, signaling systems, alarm systems, remote control systems, local loud speaker and communication systems, ventilation piping, live parts, lightning surge protection, and grounding. Compliance with these guidelines will constitute one means, but not the only means, of compliance with this paragraph.

(c) *Conducts.* All conduits shall be threaded and shall be made wrench-tight. Where it is impractical to make a threaded joint tight, a bonding jumper shall be utilized.

(Information collection requirements contained in paragraph (b)(2)(ii) were approved by the Office of Management and Budget under control number 1218 -0130)

§1926.408 Special systems.

(a) *Systems over 600 volts, nominal.* Paragraphs (a)(1) through (a)(4) of this section contain general requirements for all circuits and equipment operated at over 600 volts.

(1) *Wiring methods for fixed installations*—(i) *Above ground.* Above-ground conductors shall be installed in rigid metal conduit, in intermediate metal conduit, in cable trays, in cablebus, in other suitable raceways, or as open runs of metal-clad cable designed for the use and purpose. However, open runs of non-metallic-sheathed cable or of bare conductors or busbars may be installed in locations which are accessible only to qualified persons. Metallic shielding components, such as tapes, wires, or braids for conductors, shall be grounded. Open runs of insulated wires and cables having a bare lead sheath or a braided outer covering shall be supported in a manner designed to prevent physical damage to the braid or sheath.

(ii) *Installations emerging from the ground.* Conductors emerging from the ground shall be enclosed in raceways. Raceways installed on poles shall be of rigid metal conduit, intermediate metal conduit, PVC schedule 80 or equivalent extending from the ground line up to a point 8 feet (2.44 m) above finished grade. Conductors entering a building shall be protected by an enclosure from the ground line to the point of entrance. Metallic enclosures shall be grounded.

(2) *Interrupting and isolating devices*—(i) Circuit breakers. Circuit breakers located indoors shall consist of metal-enclosed or fire-resistant, cell-mounted units. In locations accessible only to qualified personnel, open mounting of circuit breakers is permitted. A means of indicating the open and closed position of circuit breakers shall be provided.

(ii) *Fused cutouts.* Fused cutouts installed in buildings or transformer vaults shall be of a type identified for the purpose. They shall be readily accessible for fuse replacement.

(iii) *Equipment isolating means.* A means shall be provided to completely isolate equipment for inspection and repairs. Isolating means which are not designed to interrupt the load current of the circuit shall be either interlocked with a circuit interrupter or provided with a sign warning against opening them under load.

(3) *Mobile and portable equipment*—(i) *Power cable connections to mobile machines.* A metallic enclosure shall be provided on the mobile machine for enclosing the terminals of the power cable. The enclosure shall include provisions for a solid connection for the ground wire(s) terminal to ground effectively the machine frame. The method of cable termination used shall prevent any strain or pull on the cable from stressing the electrical connections. The enclosure shall have provision for locking so only authorized qualified persons may open it and shall be marked with a sign warning of the presence of energized parts.

(ii) *Guarding live parts.* All energized switching and control parts shall be enclosed in effectively grounded metal cabinets or enclosures. Circuit breakers and protective equipment shall have the operating means projecting through the metal cabinet or enclosure so these units can be reset without locked doors being opened. Enclosures and metal cabinets shall be locked so that only authorized qualified persons have access and shall be marked with a sign warning of the presence of energized parts. Collector ring assemblies on revolving-type machines (shovels, draglines, etc.) shall be guarded.

(4) *Tunnel installations*—(i) *Application.* The provisions of this paragraph apply to installation and use of high-voltage power distribution and utilization equipment which is associated with tunnels and which is portable and/or mobile, such as substations, trailers, cars, mobile shovels, draglines, hoists, drills, dredges, compressors, pumps, conveyors, and underground excavators

(ii) *Conductors.* Conductors in tunnels shall be installed in one or more of the following:

(A) Metal conduit or other metal raceway.

(B) Type MC cable,or

(C) Other suitable multiconductor cable.

Conductors shall also be so located or guarded as to protect them from physical damage. Multiconductor portable cable may supply mobile equipment. An equipment grounding conductor shall be run with circuit conductors inside the metal raceway or inside the multiconductor cable jacket. The equipment grounding conductor may be insulated or bare.

(iii) *Guarding live parts.* Bare terminals of transformers, switches, motor controllers, and other equipment shall be enclosed to prevent accidental contact with energized parts. Enclosures for use in tunnels shall be drip-proof, weatherproof, or submersible as required by the environmental conditions.

(iv) *Disconnecting means.* A disconnecting means that simultaneously opens all ungrounded conductors shall be installed at each transformer or motor location.

(v) *Grounding and bonding.* All nonenergized metal parts of electric equipment and metal raceways and cable sheaths shall be grounded and bonded to all metal pipes and rails at the portal and at intervals not exceeding 1000 feet (305 m) throughout the tunnel.

(b) *Class 1, Class 2, and Class 3 remote control, signaling, and power limited circuits*—(1) *Classification.* Class 1, Class 2, or Class 3 remote control, signaling, or power-limited circuits are characterized by their usage and electrical power limitation which differentiates them from light and power circuits. These circuits are classified in accordance with their respective voltage and power limitations as summarized in paragraphs (b)(1)(i) through (b)(1)(iii) of this section.

(i) *Class 1 circuits*—(A) A Class 1 power-limited circuit is supplied from a source having a rated output of not more then 30 volts and 1000 volt-amperes.

(B) A Class 1 remote control circuit or a Class 1 signaling circuit has a voltage which does not exceed 600 volts; however, the power output of the source need not be limited.

(ii) *Class 2 and Class 3 circuits*—(A) Power for Class 2 and Class 3 circuits is limited either inherently (in which no overcurrent protection is required) or by a combination of a power source and overcurrent protection.

(B) The maximum circuit voltage is 150 volts AC or DC for a Class 2 inherently limited power source, and 100 volts AC or DC for a Class 3 inherently limited power source.

(C) The maximum circuit voltage is 30 volts AC and 60 volts DC for a Class 2 power source limited by overcurrent protection, and 150 volts AC or DC for a

Class 3 power source limited by overcurrent protection.

(iii) *Application.* The maximum circuit voltages in paragraphs (b)(1)(i) and (b)(1)(ii) of this section apply to sinusoidal AC or continuous DC power sources, and where wet contact occurrence is not likely.

(2) *Marking.* A Class 2 or Class 3 power supply unit shall not be used unless it is durably marked where plainly visible to indicate the class of supply and its electrical rating.

(c) *Communications systems*—(1) *Scope.* These provisions for communication systems apply to such systems as central-station connected and non-central-station-connected telephone circuits, radio receiving and transmitting equipment, and outside wiring for fire and burglar alarm, and similar central station systems. These installation need not comply with the provisions of §§1926.403 through 1926.408(b), except §1926.404(a)(1)(ii) and §1926.407.

(2) *Protective devices*—(i) *Circuits exposed to power conductors.* Communication circuits so located as to be exposed to accidental contact with light or power conductors operating at over 300 volts shall have each circuit so exposed provided with an approved protector.

(ii) *Antenna lead-ins.* Each conductor of a lead-in from an outdoor antenna shall be provided with an antenna discharge unit or other means that will drain static charges from the antenna system.

(3) *Conductor location*—(i) *Outside of buildings*—(A) Receiving distribution lead-in or aerial-drop cables attached to buildings and lead-in conductors to radio transmitters shall be so installed as to avoid the possibility of accidental contact with electric light of power conductors.

(B) The clearance between lead-in conductors and any lightning protection conductors shall not be less than 6 feet (1.83 m).

(ii) *On poles.* Where practicable, communication conductors on poles shall be located below the light or power conductors. Communications conductors shall not be attached to a crossarm that carries light or power conductors.

(iii) *Inside of building.* Indoor antennas, lead-ins, and other communication conductors attached as open conductors to the inside of buildings shall be located at least 2 inches (50.8 mm) from conductors of any light or power or Class 1 circuits unless a special and equally protective method of conductor separation is employed.

(4) *Equipment location.* Outdoor metal structures supporting antennas, as well as self-supporting antennas such as vertical rods or dipole structures, shall be located as far away from overhead conductors of electric light and power circuits of over 150 volts to ground as necessary to avoid the possibility of the antenna or structure falling into or making accidental contact with such circuits.

(5) *Grounding*—(i) *Lead-in conductors.* If exposed to contact with electric light or power conductors, the metal shealth of aerial cables entering buildings shall be grounded or shall be interrupted close to the entrance to the building by an insulating joint or equivalent device. Where protective devices are used, they shall be grounded.

(ii) *Antenna structures.* Masts and metal structures supporting antennas shall be permanently and effectively grounded without splice or connection in the ground conductor.

(iii) *Equipment enclosures.* Transmitters shall be enclosed in a metal frame or grill or separated from the operating space by a barrier, all metallic parts of which are effectively connected to ground. All external metal bandies and controls accessible to the operating personnel shall be effectively grounded. Unpowered equipment and enclosures shall be considered grounded where connected to an attached coaxial cable with an effectively grounded metallic shield.

(Information collection requirements contained in paragraph (b)(2) were approved by the Office of Management and Budget under control number 1218-0130)

§§1926.409–1926.415 [Reserved]

Safety-Related Work Practices

§1926.416 General requirements.

(a) *Protection of employees*—(1) No employer shall permit an employee to work in such proximity to any part of an electric power circuit that the employee could contact the electric power circuit in the course of work, unless the employee is protected against electric shock by deenergizing the circuit and grounding it or by guarding it effectively by insulation or other means.

(2) In work areas where the exact location of underground electric powerlines is unknown, employees using jack-hammers, bars, or other hand tools which may contact a line shall be provided with insulated protective gloves.

(3) Before work is begun the employer shall ascertain by inquiry or direct observation, or by instruments, whether any part of an energized electric power circuit, exposed or concealed, is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact with the electric power circuit. The employer shall post and maintain proper warning signs where such a circuit exists. The employer shall advise employees of the location of such lines, the hazards involved, and the protective measures to be taken.

(4) *Work on energized equipment.* Only qualified persons may work on electric circuit parts or equipment that have not been deenergized under the procedures of § 1926.417(d) of this section. Such persons shall be capable of working safely on energized circuits and shall be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools.

[1926.416(a)(4) added by 58 FR 35077, June 30, 1993]

(b) *Passageways and open spaces*—(1) Barriers or other means of guarding shall be provided to ensure that workspace for electrical equipment will not be used as a passageway during periods when energized parts of electrical equipment are exposed.

(2) Working spaces, walkways, and similar locations shall be kept clear of cords so as not to create a hazard to employees.

(c) *Load ratings.* In existing installations, no changes in circuit protection shall be made to increase the load in excess of the load rating of the circuit wiring.

(d) *Fuses.* When fuses are installed or removed with one or both terminals energized, special tools insulated for the voltage shall be used.

(e) *Cords and cables.* (1) Worn or frayed electric cords or cables shall not be used.

(2) Extension cords shall not be fastened with staples, hung from nails, or suspended by wire.

(f)(1) *Interlocks.* Only a qualified person following the requirements of paragraph (c) of this section may defeat an electrical safety interlock, and then only temporarily while he or she is working on the equipment. The interlock system shall be returned to its operable condition when this work is completed.

[1926.416(f) added by 58 FR 35077, June 30, 1993]

(2) *Portable electric equipment—Handling.* Portable equipment shall be handled in a manner which will not cause damage. Flexible electric cords connected to equipment may not be used for raising or lowering the equipment. Flexible cords may not be fastened with staples or otherwise hung in such a fashion as could damage the outer jacket or insulation.

(3) *Visual inspection.* When an attachment plug is to be connected to a receptacle (including an on a cord set), the relationship of the plug and receptacle contacts shall first be checked to ensure that they are of proper mating configurations.

(4) *Connecting attachment plugs.* (i) Employees' hands may not be wet when plugging and unplugging flexible cords and cord and plug connected equipment, if energized equipment is involved.

(ii) Energized plug and receptacle connections may be handled only with insulating protective equipment if the condition of the connection could provide a conducting path to the employee's hand (if, for example, a cord connector is wet from being immersed in water).

(iii) Locking type connectors shall be properly secured after connection.

(5) *Routine opening and closing of electric power and lighting circuits.* Load rated switches, circuit breakers, or other devices specifically designed as disconnecting means shall be used for the opening, reversing, or closing of circuits under load conditions. Cable connectors not of the load break type, fuses, terminal lugs, and cable splice connections may not be used for such purposes, except in an emergency.

(6) *Reclosing circuits after protective device operation.* After a circuit is deenergized by a circuit protective device, the circuit protective device, the circuit may not be manually reenergized until it has been determined that the equipment and circuit can be safely energized. The repetitive manual reclosing of circuit breakers or reenergizing circuits through replaced fuses is prohibited.

Note: When it can be determined from the design of the circuit and the overcurrent devices involved that the automatic operation of a device was caused by an overload rather than a fault condition, no examination of the circuit or connected equipment is needed before the circuit is reenergized.

(7) *Test instruments and equipment—Use.* Only qualified persons may perform testing work on electric circuits or equipment.

(8) *Visual inspection.* Test instruments and equipment and all associated test leads, cables, power cords, probes, and connectors shall be visually inspected for external defects and damage before the equipment is used. If there is a defect or evidence of damage that might expose an employee to injury, the defective or damaged item shall be removed from service, and no employee may use it until repairs and tests necessary to render the equipment safe have been made.

(9) *Rating of equipment.* Test instruments and equipment and their accessories shall be rated for the circuits and equipment to which they will be connected and shall be designed for the environment in which they will be used.

(10) *Occasional use of flammable or ignitable materials.* Where flammable materials are present only occasionally, electric equipment capable of igniting them shall not be used, unless measures are taken to prevent hazardous conditions from developing. Such materials include, but are not limited to: flammable gases, vapors, or liquids; combustible dust; and ignitible fibers or flyings.

(g) *Use of equipment.* (1) *Work on energized equipment.* Only qualified persons may work on electric circuit parts or equipment that have not been deenergized under the procedures of paragraph (b) of this section. Such persons shall be capable of working safely on energized circuits and shall be familiar with the proper use of special precautionary techniques, personal protective equipment, insulating and shielding materials, and insulated tools.

[1926.416(g) added by 58 FR 35077, June 30, 1993]

(2) *Overhead lines.* If work is to be performed near overhead lines, the lines shall be deenergized and grounded, or other protective measures shall be provided before work is started. If the lines are to be deenergized, arrangements shall be made with the person or organization that operates or controls the electric circuits involved to deenergize and ground them. If protective measures, such as guarding, isolating, or insulating, are provided, these precautions shall prevent employees from contacting such lines directly with any part of their body or indirectly through conductive materials, tools, or equipment.

(i) *Unqualified persons.* (A) When an unqualified person is working in an elevated position near overhead lines, the location shall be such that the person and the longest conductive object he or she may contact cannot come closer to any unguarded, energized overhead line than the following distances:

(1) For voltages to ground 50kV or below—10 feet (305 cm);

(2) For voltages to ground over 50kV—10 feet (305 cm) plus 4 inches (10 cm) for every 10kV over 50kV.

(B) When an unqualified person is working on the ground in the vicinity of overhead lines, the person may not bring any conductive object closer to unguarded, energized overhead lines than the distances given in paragraph (g)(2)(i)(A) of this section.

Note: For voltages normally encountered with overhead power line, objects which do not have an insulating rating for the voltage involved are considered to be conductive.

(ii) *Qualified persons.* When a qualified person is working in the vicinity of overhead lines, whether in an elevated position or on the ground, the person may not approach or take any conductive object without an approved insulating handle closer to exposed energized parts than shown in Table K-2 unless:

(A) The person is insulated from the energized part (gloves, with sleeves if necessary, rated for the voltage involved are considered to be insulation of the person from the energized part on which work is performed), or

(B) The energized part is insulated both from all other conductive objects at a different potential and from the person, or

(C) The person is insulated from all conductive objects at a potential different from that of the energized part.

Table K-2—Approach Distances for Qualified Employees—Alternating Current

Voltage range (phase to phase)	Minimum approach distance
300V and less	Avoid contact
Over 300V, not over 750V	1 ft. 0 in. (30.5 cm).
Over 750V, not over 2kV	1 ft. 6 in. (46 cm).
Over 2kV, not over 15kV	2 ft. 0 in. (61 cm).
Over 15kV, not over 37kV	3 ft. 0 in. (91 cm).
Over 37kV, not over 87.5kV	3 ft. 6 in. (107 cm).
Over 87.5kV, not over 121kV	4 ft. 0 in. (122 cm).
Over 121kV, not over 140kV	4 ft. 6 in. (137 cm).

(iii) *Vehicular and mechanical equipment.* (A) Any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines shall be operated so that a clearance of 10 ft. (305 cm) is maintained. If the voltage is higher than 50kV, the clearance shall be increased 4 in. (10 cm) for every 10kV over that voltage. However, under any of the following conditions, the clearance may be reduced:

(1) If the vehicle is in transit with its structure lowered, the clearance may be reduced to 4 ft. (122 cm). If the voltage is higher than 50kV, the clearance shall be increased 4 in. (10 cm) for every 10 kV over that voltage.

(2) If insulating barriers are installed to prevent contact with the lines, and if the barriers are rated for the voltage of the line being guarded and are not a part of or an attachment to the the vehicle or its raised structure, the clearance may be reduced to a distance within the designed working dimensions of the insulating barrier.

(3) If the equipment is an aerial lift insulated for the voltage involved, and if the work is performed by a qualified person, the clearance (between the uninsulated portion of the aerial lift and the power line) may be reduced to the distance given in Table K-2.

(B) Employees standing on the ground may not contact the vehicle or mechanical equipment or any of the structure that provides a conductive path to employees on the ground) can come closer to the line than permitted in paragraph (g)(2)(iii) of this section.

(C) If any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines is intentionally grounded, employees working on the ground near the point of grounding may not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades or insulation, shall be taken to protect employees from hazardous ground potentials, depending on earth resistivity and fault currents, which can develop within the first few feet or more outward from the grounding point.

(3) *Illumination.* (i) Employees may not enter spaces containing exposed energized parts, unless illumination is provided that enables the employees to perform the work safely.

(ii) Where lack of illumination or an obstruction precludes observation of the work to be performed, employees may not perform tasks near exposed energized parts. Employees may not reach blindly into areas which may contain energized parts.

(4) *Confined or enclosed work spaces.* When an employee works in a confined or enclosed space (such as a manhole or vault) that contains exposed energized parts, the employer shall provide, and the employee shall use, protective shields, protective barriers, or insulating materials as necessary to avoid inadvertent contact with these parts. Doors, hinged panels, and the like shall be secured to prevent their swinging into an employee and causing the employee to contact exposed energized parts.

(5) *Conductive materials and equipment.* Conductive materials and equipment that are in contact with any part of an employee's body shall be handled in a manner that will prevent them from contacting exposed energized conductors or circuit parts. If an employee must handle long dimensional conductive objects (such as ducts and pipes) in areas with exposed live parts, the employer shall institute work practices (such as the use of insulation, guarding, and material handling techniques) which will minimize the hazard.

(6) *Portable ladders.* Portable ladders shall have nonconductive siderails if they are used where the employee or the ladder could contact exposed energized parts.

(7) *Conductive apparel.* Conductive articles of jewelry and clothing (such a watch bands, bracelets, rings, key chains, necklaces, metalized aprons, cloth with conductive thread, or metal headgear) may not be worn if they might contact exposed energized parts. However, such articles may be worn if they are rendered nonconductive by covering, wrapping, or other insulating means.

(8) *Housekeeping duties.* Where live parts present an electrical contact hazard, employees may not perform housekeeping duties at such close distances to the parts that there is a possibility of contact, unless adequate safeguards (such as insulating equipment or barriers) are provided. Electrically conductive cleaning materials (including conductive solids such as steel wool, metalized cloth, and silicon carbide, as well as conductive liquid solutions) may not be used in proximity to energized parts unless procedures are followed which will prevent electrical contact.

§1926.417 Lockout and tagging of circuits.

(a) *Controls.* Controls that are to be deactivated during the course of work on energized or deenergized equipment or circuits shall be tagged.

(b) *Equipment and circuits.* Equipment or circuits that are deenergized shall be rendered inoperative and shall have tags attached at all points where such equipment or circuits can be energized.

(c) *Tags.* Tags shall be placed to identify plainly the equipment or circuits being worked on.

(d) *Lockout and tagging.* While any employee is exposed to contact with parts of fixed electric equipment or circuits which have been deenergized, the circuits energizing the parts shall be locked out or tagged or both in accordance with the requirements of this paragraph. The requirements shall be followed in the order in which they are presented (*i.e.*, paragraph (d)(1) first, then paragraph (d)(2), etc.).

[1926.417(d) added by 58 FR 35077, June 30, 1993]

Note 1: As used in this section, fixed equipment refers to equipment fastened in place or connected by permanent wiring methods.

Note 2: Lockout and tagging procedures that comply with paragraphs (c) through (f) of 1910.147 will also be deemed to comply with paragraph (d) of this section provided that:

(1) The procedures address the electrical safety hazards covered by this subpart; and

(2) The procedures also incorporate the requirements of paragraphs (d)(3)(iv) and (d)(4)(ii) of this section.

(1) *Procedures.* The employer shall maintain a written copy of the procedures outlined in paragraph (d) and shall make it available for inspection by employees and by the Assistant Secretary of Labor and his or her authorized representatives.

Note: The written procedures may be in the form of a copy of paragraph (b) of this section.

(2) *Deenergizing equipment.* (i) Safe procedures for deenergizing circuits and equipment shall be determined before circuits or equipment are deenergized.

(ii) The circuits and equipment to be worked on shall be disconnected from all electric energy sources. Control circuit devices, such as push buttons, selector switches, and interlocks, may not be used as the sole means for deenergizing circuits or equipment. Interlocks for electric equipment may not be used as a substitute for lockout and tagging procedures.

(iii) Stored electric energy which might endanger personnel shall be released. Capacitors shall be discharged and high capacitance elements shall be short-circuited and grounded, if the stored electric energy might endanger personnel.

Note: If the capacitors or associated equipment are handled in meeting this requirement, they shall be treated as energized.

(iv) Stored non-electrical energy in devices that could reenergize electric circuit parts shall be blocked or relieved to the extent that the circuit parts could not be accidentally energized by the device.

(3) *Application of locks and tags.* (i) A lock and a tag shall be placed on each disconnecting means used to deenergize circuits and equipment on which work is to be performed, except as provided in paragraphs (d)(3) (iii) and (v) of this section. The lock shall be attached so as to prevent persons from operating the disconnecting means unless they resort to undue force or the use of tools.

(ii) Each tag shall contain a statement prohibiting unauthorized operation of the disconnecting means and removal of the tag.

(iii) If a lock cannot be applied, or if the employer can demonstrate that tagging procedures will provide a level of safety equivalent to that obtained by the use of a lock, a tag may be used without a lock.

(iv) A tag used without a lock, as permitted by paragraph (d)(3)(iii) of this section, shall be supplemented by at least one additional safety measure that provides a level of safety equivalent to that obtained by use of a lock. Examples of additional safety measures include the removal of an isolating circuit element, blocking of a controlling switch, or opening of an extra disconnecting device.

(v) A lock may be placed without a tag only under the following conditions:

(A) Only one circuit or piece of equipment is deenergized, and

(B) The lockout period does not extend beyond the work shift, and

(C) Employees exposed to the hazards associated with reenergizing the circuit or equipment are familiar with this procedure.

(4) *Verification of deenergized condition.* The requirements of this paragraph shall be met before any circuits or equipment can be considered and worked as deenergized.

(i) A qualified person shall operate the equipment operating controls or otherwise verify that the equipment cannot be restarted.

(ii) A qualified person shall use test equipment to test the circuit elements and electrical parts of equipment to which employees will be exposed and shall verify that the circuit elements and equipment parts are deenergized. The test shall also determine if any energized condition exists as a result of inadvertently induced voltage or unrelated voltage backfeed even though specific parts of the circuit have been deenergized and presumed to be safe. If the circuit to be tested is over

600 volts, nominal, the test equipment shall be checked for proper operation immediately after this test.

(v) *Reenergizing equipment.* These requirements shall be met, in the order given, before circuits or equipment are reenergized, even temporarily.

(i) A qualified person shall conduct tests and visual inspections, as necessary, to verify that all tools, electrical jumpers, shorts, grounds, and other such devices have been removed, so that the circuits and equipment can be safely energized.

(ii) Employees exposed to the hazards associated with reenergizing the circuit or equipment shall be warned to stay clear of circuits and equipment.

(iii) Each lock and tag shall be removed by the employee who applied it or under his or her direct supervision. However, if this employee is absent from the workplace, then the lock or tag may be removed by a qualified person designated to perform this task provided that:

(A) The employer ensures that the employee who applied the lock or tag is not available at the workplace, and

(B) The employer ensures that the employee is aware that the lock or tag has been removed before he or she resumes work at that workplace.

(iv) There shall be a visual determination that all employees are clear of the circuits and equipment.

§§1926.418–1926.430 [Reserved]

Safety-Related Maintenance and Environmental Considerations

§1926.431 Maintenance of equipment.

The employer shall ensure that all wiring components and utilization equipment in hazardous locations are maintained in a dust-tight, dust-ignition-proof, or explosion-proof condition, as appropriate. There shall be no loose or missing screws, gaskets, threaded connections, seals, or other impairments to a tight condition.

§1926.432 Environmental deterioration of equipment.

(a) *Deteriorating agents*—(1) Unless identified for use in the operating environment, no conductors or equipment shall be located:

(i) In damp or wet locations;

(ii) Where exposed to gases, fumes, vapors, liquids, or other agents having a deteriorating effect on the conductors or equipment; or

(iii) Where exposed to excessive temperatures.

(2) Control equipment, utilization equipment, and busways approved for use in dry locations only shall be protected against damage from the weather during building construction.

(b) *Protection against corrosion.* Metal raceways, cable armor, boxes, cable sheathing, cabinets, elbows, couplings, fittings, supports, and support hardware shall be of materials appropriate for the environment in which they are to be installed.

§§1926.433–1926.440 [Reserved]

Safety Requirements for Special Equipment

§1926.441 Batteries and battery charging.

(a) *General requirements*—(1) Batteries of the unsealed type shall be located in enclosures with outside vents or in well ventilated rooms and shall be arranged so as to prevent the escape of fames, gases, or electrolyte spray into other areas.

(2) Ventilation shall be provided to ensure diffusion of the gases from the battery and to prevent the accumulation of an explosive mixture.

(3) Racks and trays shall be substantial and shall be treated to make them resistant to the electrolyte.

(4) Floors shall be of acid resistant construction unless protected from acid accumulations.

(5) Face shields, aprons, and rubber gloves shall be provided for workers handling acids or batteries.

(6) Facilities for quick drenching of the eyes and body shall be provided within 25 feet (7.62 m) of battery handling areas.

(7) Facilities shall be provided for flushing and neutralizing spilled electrolyte and for fire protection.

(b) *Charging*—(1) Battery charging installations shall be located in areas designated for that purpose.

(2) Changing apparatus shall be protected from damage by trucks.

(3) When batteries are being charged, the vent caps shall be kept in place to avoid electrolyte spray. Vent caps shall be maintained in functioning condition.

§§1926.442-1926.448 [Reserved]

Definitions

§1926.449 Definitions applicable to this subpart.

The definitions given in this section apply to the terms used in Subpart K. The definitions given here for "approved" and "qualified person" apply, instead of the definitions given in §1926.32, to the use of these terms in Subpart K.

Acceptable. An installation or equipment is acceptable to the Assistant Secretary of Labor, and approved within the meaning of this Subpart K;

(a) If it is accepted, or certified, or listed, or labeled, or otherwise determined to be safe by a qualified testing laboratory capable of determining the suitability of materials and equipment for installation and use in accordance with this standard; or

(b) With respect to an installation or equipment of a kind which no qualified testing laboratory accepts, certifies, lists, labels, or determines to be safe, if it is inspected or tested by another Federal agency, or by a State, municipal, or other local authority responsible for enforcing occupational safety provisions of the National Electrical Code, and found in compliance with those provisions; or

(c) With respect to custom-made equipment or related installations which are designed, fabricated for, and intended for use by a particular customer, if it is determined to be safe for its intended use by its manufacturer on the basis of test data which the employer keeps and makes available for inspection to the Assistant Secretary and his authorized representatives.

Accepted. An installation is "accepted" if it has been inspected and found to be safe by a qualified testing laboratory.

Accessible. (As applied to wiring methods.) Capable of being removed or exposed without damaging the building structure or finish, or not permanently closed in by the structure or finish of the building. (See "*concealed*" and " *exposed.*")

Accessible. (As applied to equipment.) Admitting close approach; not guarded by locked doors, elevation, or other effective means (See "*Readily accessible.*")

Ampacity. The current in amperes a conductor can carry continuously under the conditions of use without exceeding its temperature rating.

Appliances. Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions.

Approved. Acceptable to the authority enforcing this Subpart. The authority enforcing this Subpart is the Assistant Secretary of Labor for Occupational Safety and Health. The definition of "acceptable" indicates what is acceptable to the Assistant Secretary of Labor, and therefore approved within the meaning of this Subpart.

Askarel. A generic term for a group of nonflammable synthetic chlorinated hydrocarbons used as electrical insulating media. Askarels of various compositional types are used. Under arcing conditions the gases produced, while consisting predominantly of noncombustible hydrogen chloride, can include varying amounts of combustible gases depending upon the askarel type.

Attachment plug (Plug cap) (*Cap*). A device which, by insertion in a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors connected permanently to the receptacle.

Automatic. Self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength pressure, temperature, or mechanical configuration.

Bare conductor. See "*Conductor.*"

Bonding. The permanent joining of metallic parts to form an electrically conductive path which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

Bonding jumper. A reliable conductor to assure the required electrical, conductivity between metal parts required to be electrically connected.

Branch circuit. The circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

Building. A structure which stands alone or which is cut off from adjoining structures by fire walls with all openings therein protected by approved fire doors.

Cabinet. An enclosure designed either for surface or flush mounting, and provided with a frame, mat, or trim in which a swinging door or doors are or may be hung.

Certified. Equipment is "certified" if it:

(a) Has been tested and found by a qualified testing laboratory to meet applicable test standards or to be safe for use in a specified manner and

(b) Is of a kind whose production is periodically inspected by a qualified testing laboratory. Certified equipment must bear a label, tag, or other record of certification.

Circuit breaker—(a) (600 volts nominal, or less.) A device designed to open and close a circuit by nonautomatic means and to open the circuit automatically on a predetermined overcurrent without injury to itself when properly applied within its rating.

(b) (Over 600 volts, nominal.) A switching device capable of making, carrying, and breaking currents under normal circuit conditions, and also making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions, such as those of short circuit.

Class I locations. Class I locations are those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures. Class I locations include the following:

(a) *Class I, Division 1.* A Class I Division 1 location is a location:

(1) In which ignitible concentrations of flammable gases or vapors may exist under normal operating conditions; or

(2) In which ignitible concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or

(3) In which breakdown or faulty operation of equipment or processes might release ignitible concentrations of flammable gases or vapors, and might also cause simultaneous failure of electric equipment.

Note: This classification usually includes locations where volatile flammable liquids or liquefied flammable gases are transferred from one container to another, interiors of spray booths and areas in the vicinity of spraying and painting operations where volatile flammable solvents are used; locations containing open tanks of vats of volatile flammable liquids; drying rooms or compartments for the evaporation of flammable solvents; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; and all other locations where ignitible concentrations of flammable vapors or gases are likely to occur in the course of normal operations.

(b) *Class I, Division 2.* A Class I, Division 2 location is a location:

(1) In which volatile flammable liquids or flammable gases are handled, processed, or used, but in which the hazardous liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems, or in case of abnormal operation of equipment; or

(2) In which ignitible concentrations of gases or vapors are normally prevented by positive mechanical ventilation, and which might become hazardous through failure or abnormal operations of the ventilating equipment; or

(3) That is adjacent to a Class I, Division 1 location, and to which ignitible concentrations of gases or vapors might occasionally be communicated unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air, and effective safeguards against ventilation failure are provided.

Note: This classification usually includes locations where volatile flammable liquids or flammable gases or vapors are used, but which would become hazardous only in case of an accident or of some unusual operating condition. The quantity of flammable material that might escape in case of accident, the adequacy of ventilating equipment, the total area involved, and the record of the industry or business with respect to explosions or fires are all factors that merit consideration in determining the classification and extent of each location.

Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazardous condition even though used for flammable liquids or gases. Locations used for the storage of flammable liquids or of liquefied or compressed gases in sealed containers would not normally be considered hazardous unless also subject to other hazardous conditions.

Electrical conduits and their associated enclosures separated from process fluids by a single seal or barrier are classed as a Division 2 location if the outside of the conduit and enclosures is a nonhazardous location.

Class II locations. Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations include the following:

(a) *Class II, Division 1.* A Class II, Division 1 location is a location:

(1) In which combustible dust is or may be in suspension in the air under normal operating conditions, in quantities sufficient to produce explosive or ignitible mixtures; or

(2) Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitible mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, operation of protection devices, or from other causes, or

(3) In which combustible dusts of an electrically conductive nature may be present.

Note: Combustible dusts which are electrically nonconductive include dusts produced in the handling and processing of grain and grain products, pulverized sugar and cocoa, dried egg and milk powders, pulverized spices, starch and pastes, potato and woodflour, oil meal from beans and seed, dried hay, and other organic materials which may produce combustible dusts when processed or handled. Dusts containing magnesium or aluminum are particularly hazardous and the use of extreme caution is necessary to avoid ignition and explosion.

(b) *Class II, Division 2.* A Class II, Division 2 location is a location in which:

(1) Combustible dust will not normally be in suspension in the air in quantities sufficient to produce explosive or ignitible mixtures, and dust accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus: or

(2) Dust may be in suspension in the air as a result of infrequent malfunctioning of handling or processing equipment, and dust accumulations resulting therefrom may be ignitible by abnormal operation or failure of electrical equipment or other apparatus.

Note: This classification includes locations where dangerous concentrations of suspended dust would not be likely but where dust accumulations might form on or in the vicinity of electric equipment. These areas may contain equipment from which appreciable quantities of dust would escape under abnormal operating conditions or be adjacent to a Class II Division 1 location, as described above, into which an explosive or ignitible concentration of dust may be put into suspension under abnormal operating conditions.

Class III locations. Class III locations are those that are hazardous because of the presence of easily ignitible fibers or flyings but in which such fibers or flyings are not likely to be in suspension in the air in quantities sufficient to produce ignitible mixtures. Class 111 locations include the following:

(a) *Class III, Division 1.* A Class III, Division 1 location is a location in which easily ignitible fibers or materials producing combustible, flyings are handled, manufactured, or used.

Note: Easily ignitible fibers and flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, sawdust, woodchips, and other material of similar nature.

(b) *Class III, Division 2.* A Class III, Division 2 location is a location in which easily ignitible fibers are stored or handled, except in process of manufacture.

Collector ring. A collector ring is an assembly of slip rings for transferring electrical energy from a stationary to a rotating member.

Concealed. Rendered inaccessible by the structure or finish of the building. Wires in concealed raceways are considered concealed, even though they may become accessible by withdrawing them. [See "*Accessible.* (As applied to wiring methods.)"]

Conductor—(a) *Bare.* A conductor having no covering or electrical insulation whatsoever.

(b) *Covered.* A conductor encased within material of composition or thickness that is not recognized as electrical insulation.

(c) *Insulated.* A conductor encased within material of composition and thickness that is recognized as electrical insulation.

Controller. A device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected.

Covered conductor. See "*Conductor.*"

Cutout. (Over 600 volts, nominal.) An assembly of a fuse support with either a fuseholder, fuse carrier, or disconnecting blade. The fuseholder or fuse carrier may include a conducting element (fuse link), or may act as the disconnecting blade by the inclusion of a nonfusible member.

Cutout box. An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper. (See "Cabinet.")

Damp location. See "Location."

Dead front. Without live parts exposed to a person on the operating side of the equipment.

Device. A unit of an electrical system which is intended to carry but not utilize electric energy.

Disconnecting means. A device or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

Disconnecting (or Isolating) switch. (Over 600 volts, nominal.) A mechanical switching device used for isolating a circuit or equipment from a source of power.

Dry location. See "Location."

Enclosed. Surrounded by a case, housing, fence or walls which will prevent persons from accidentally contacting energized parts.

Enclosure. The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts, or to protect the equipment from physical damage.

Equipment. A general term including material, fittings, devices, appliances, fixtures, apparatus, and the like, used as a part of or in connection with an electrical installation.

Equipment grounding conductor. See "*Grounding conductor equipment* ."

Explosion-proof apparatus. Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes or explosion of the gas or vapor within, and which operates at such an external temperature that it will not ignite a surrounding flammable atmosphere.

Exposed. (As applied to live parts.) Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. (See "*Accessible* and *Concealed.*")

Exposed. (As applied to wiring methods.) On or attached to the surface or behind panels designed to allow access. [See "*Accessible.* (As applied to wiring methods.)"]

Exposed. (For the purposes of §1926.408(d). Communications systems.) Where the circuit is in such a position that in case of failure of supports or insulation, contact with another circuit may result.

Externally operable. Capable of being operated without exposing the operator to contact with live parts.

Feeder. All circuit conductors between the service equipment, or the generator switchboard of an isolated plant, and the final branch-circuit overcurrent device.

Festoon lighting. A string of outdoor lights suspended between two points more than 15 feet (4.57 m) apart.

Fitting. An accessory such as a locknut, bushing, or other part of a wiring system that is intended primarily to perform a mechanical: rather than an electrical function.

Fuse. (Over 600 volts, nominal.) An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it. A fuse comprises all the parts that form a unit capable of performing the prescribed functions. It may or may not be the complete device necessary to connect it into an electrical circuit.

Ground. A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Grounded. Connected to earth or to some conducting body that serves in place of the earth.

Grounded effectively (Over 600 volts, nominal.) Permanently connected to earth through a ground connection of sufficiently low impedance and having sufficient ampacity that ground fault current which may occur cannot build up to voltages dangerous to personnel.

Grounded conductor. A system or circuit conductor that is intentionally grounded.

Grounding conductor. A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes.

Grounding conductor, equipment. The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor and/or the grounding electrode conductor at the service equipment or at the source of a separately derived system.

Grounding electrode conductor. The conductor used to connect the grounding electrode to the equipment grounding conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system.

Ground-fault circuit interrupter. A device for the protection of personnel that functions to deenergize a circuit or portion thereof within an established period of time when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit.

Guarded. Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach to a point of danger or contact by persons or objects.

Hoistway. Any shaftway, hatchway, well hole, or other vertical opening or space in which an elevator or dumbwaiter is designed to operate.

Identified (conductors or terminals). Identified, as used in reference to a conductor or its terminal, means that such conductor or terminal can be recognized as grounded.

Identified (for the use). Recognized as suitable for the specific purpose, function, use, environment, application, etc., where described as a requirement in this standard. Suitability of equipment for a specific purpose, environment, or application is determined by a qualified testing laboratory where such identification includes labeling or listing.

Insulated conductor. See "*Conductor.*"

Interrupter switch. (Over 600 volts, nominal.) A switch capable of making, carrying, and interrupting specified currents.

Intrinsically safe equipment and associated wiring. Equipment and associated wiring. Equipment and associated wiring in which any spark or thermal effect, produced either normally or in specified fault conditions, is incapable, under certain prescribed test conditions, of causing ignition of a mixture of flammable or combustible material in air in its most easily ignitable concentration.

Isolated. Not readily accessible to persons unless special means for access are used.

Isolated power system. A system comprising an isolating transformer or its equivalent, a line isolation monitor, and its ungrounded circuit conductors.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of a qualified testing laboratory which indicates compliance with appropriate standards or performance in a specified manner.

Lighting outlet. An outlet intended for the direct connection of a lampholder, a lighting fixture, or a pendant cord terminating in a lampholder.

Listed. Equipment or materials included in a list published by a qualified testing laboratory whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

Location—(a) *Damp location.* Partially protected locations under canopies, marquees, roofed open porches, and like locations, and interior locations subject to moderate degrees of moisture, such as some basements.

(b) *Dry location.* A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction.

(c) *Wet location.* Installations underground or in concrete slabs or masonry in direct contact with the earth and locations subject to saturation with water or other liquids, such as locations exposed to weather and unprotected.

Mobile X-ray. X-ray equipment mounted on a permanent base with wheels and/or casters for moving while completely assembled.

Motor control center An assembly of one or more enclosed sections having a common power bus and principally containing motor control units.

Outlet. A point on the wiring system at which current is taken to supply utilization equipment.

Overcurrent. Any current in excess of the rated current of equipment or the ampacity of a conductor. It may result from overload (see definition), short circuit, or ground fault. A current in excess of rating may be accommodated by certain equipment and conductors for a given set of conditions. Hence the rules for overcurrent protection are specific for particular situations.

Overload. Operation of equipment in excess of normal, full load rating, or of a conductor in excess of rated ampacity which, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload. (See "*Overcurrent.*")

Panelboard. A single panel or group of panel units designed for assembly in the form of a single panel; including buses, automatic overcurrent devices, and with or without switches for the control of light, heat, or power circuits; designed to be placed in a cabinet or cutout box placed in or against a wall or partition and accessible only from the front. (See "*Switchbaord.*")

Portable X-ray. X-ray equipment designed to be hand- carried.

Power fuse. (Over 600 volts, nominal.) See "*Fuse.*"

Power outlet. An enclosed assembly which may include receptacles, circuit breakers, fuseholders, fused switches, buses and watt-hour meter mounting means; intended to serve as a means for distributing power required to operate mobile or temporarily installed equipment.

Premises wiring system. That interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed, which extends from the load end of the service drop, or load end of the service lateral conductors to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

Qualified person. One familiar with the construction and operation of the equipment and the hazards involved.

Qualified testing laboratory. A properly equipped and staffed testing laboratory which has capabilities for and which provides the following services:

(a) Experimental testing for safety of specified items of equipment and materials referred to in this standard to determine compliance with appropriate test standards or performance in a specified manner.

(b) Inspecting the run of such items of equipment and materials at factories for product evaluation to assure, compliance with the test standards;

(c) Service-value determinations through field inspections to monitor the proper use of labels on products and with authority for recall of the label in the event a hazardous product is installed;

(d) Employing a controlled procedure for identifying the listed and/or labeled equipment or materials tested; and

(e) Rendering creditable reports or findings that are objective and without bias of the tests and test methods employed.

Raceway. A channel designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this subpart. Raceways may be of metal or insulating material, and the term includes rigid metal conduit, rigid nonmetallic conduit, intermediate metal conduit, liquid tight flexible metal conduit, flexible metallic tubing, flexible metal conduit, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways, wireways and busways.

Readily accessible. Capable of being reached quickly for operation, renewal, or inspections, without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. (See "*Accessible.*")

Receptacle. A receptacle is a contact device installed at the outlet for the connection of a single attachment plug. A single receptacle is a single contact device with no other contact device on the same yoke. A multiple receptacle is a single device containing two or more receptacles.

Receptacle outlet. An outlet where one or more receptacles are installed.

Remote-control circuit. Any electric circuit that controls any other circuit through a relay or an equivalent device.

Sealable equipment. Equipment enclosed in a case or cabinet that is provided with a means of sealing or locking so that live parts cannot be made accessible without opening the enclosure. The equipment may or may not be operable without opening the enclosure.

Separately derived system. A premises wiring system whose power is derived from generator, transformer, or converter windings and has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system.

Service. The conductors and equipment for delivering energy from the electricity supply system to the wiring system of the premises served.

Service conductors. The supply conductors that extend from the street main or from transformers to the service equipment of the premises supplied.

Service drop. The overhead service conductors from the last pole or other aerial support to and including the splices, if any, connecting to the service-entrance conductors at the building or other structure.

Service-entrance conductors, overhead system. The service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop.

Service-entrance conductors, underground system. The service conductors between the terminals of the service equipment and the point of connection to the service lateral. Where service equipment is located outside the building walls, there may be no service-entrance conductors, or they may be entirely outside the building.

Service equipment. The necessary equipment, usually consisting of a circuit breaker or switch and fuses, and their accessories, located near the point of entrance of supply conductors to a building or other structure, or an otherwise defined area, and intended to constitute the main control and means of cutoff of the supply.

Service raceway. The raceway that encloses the service-entrance conductors.

Signaling circuit. Any electric circuit that energizes signaling equipment.

Switchboard. A large single panel, frame, or assembly of panels which have switches, buses, instruments, overcurrent and other protective devices mounted on the face or back or both. Switchboards are generally accessible from the rear as well as from the front and are not intended to be installed in cabinets. (See "*Panelboard.")*

Switches—(a) *General-use switch.* A switch intended for use in general distribution and branch circuits. It is rated in amperes, and it is capable of interrupting its rated current at its rated voltage.

(b) *General-use snap switch.* A form of general-use switch so constructed that it can be installed in flush device boxes or on outlet box covers, or otherwise used in conjunction with wiring systems recognized by this subpart.

(c) *Isolating switch.* A switch intended for isolating an electric circuit from the source of power. It has no interrupting rating, and it is intended to be operated only after the circuit has been opened by some other means.

(d) *Motor-circuit switch.* A switch, rated in horsepower, capable of interrupting the maximum operating overload current of a motor of the same horsepower rating as the switch at the rated voltage.

Switching devices. (Over 600 volts, nominal.) Devices designed to close and/or open one or more electric circuits. Included in this category are circuit breakers, cutouts, disconnecting (or isolating) switches, disconnecting means, and interrupter switches.

Transportable X-ray. X-ray equipment installed in a vehicle or that may readily be disassembled for transport in a vehicle.

Utilization equipment. Utilization equipment means equipment which utilizes electric energy for mechanical, chemical, heating, lighting, or similar useful purpose.

Utilization system. A utilization system is a system which provides electric power and light for employee workplaces, and includes the premises wiring system and utilization equipment.

Ventilated. Provided with a means to permit circulation of air sufficient to remove an excess of heat, fumes, or vapors.

Volatile flammable liquid. A flammable liquid having a flash point below 38 degrees C (100 degrees F) or whose temperature is above its flash point, or a Class II combustible liquid having a vapor pressure not exceeding 40 psia (276 kPa) at 38° C (100° F) whose temperature is above its flash point.

Voltage. (Of a circuit.) The greatest root-mean-square (effective) difference of potential between any two conductors of the circuit concerned.

Voltage, nominal. A nominal value assigned to a circuit or system for the purpose of conveniently designating its voltage class (as 120/240, 480Y/277, 600, etc.). The actual voltage at which a circuit operates can vary from the nominal within a range that permits satisfactory operation of equipment.

Voltage to ground. For grounded circuits, the voltage between the given conductor and that point or conductor of the circuit that is grounded: for ungrounded circuits, the greatest voltage between the given conductor and any other conductor of the circuit.

Watertight. So constructed that moisture will not enter the enclosure.

Weatherproof. So constructed or protected that exposure to the weather will not interfere with successful operation. Rainproof, raintight, or watertight equipment can fulfill the requirements for weatherproof where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.

Wet location. See "*Location.*"

Subpart L—Scaffolding

[Subpart L head revised by 55 FR 47687, November 14, 1990]

Authority: Sec. 107, Contract Work Hours and Safety Standards Act (Construction Safety Act) (40 U.S.C. 333); secs. 4, 6, 8, Occupational Safety and Health Act of 1970 (29 U.S.C. 653, 655, 657); Secretary of Labor's Order No. 12-71 (36 FR 8754), 8-76 (41 FR 25059), or 9-83 (48 FR 35736), as applicable.

§1926.450 [Reserved]

[1926.450 removed and reserved by 55 FR 47687, November 14, 1990]

§1926.451 Scaffolding.

(a) *General requirements.* (1) Scaffolds shall be erected in accordance with requirements of this section.

(2) The footing or anchorage for scaffolds shall be sound, rigid, and capable of carrying the maximum intended load without settling or displacement. Unstable objects such as barrels, boxes, loose brick, or concrete blocks, shall not be used to support scaffolds or planks.

(3) No scaffold shall be erected, moved, dismantled, or altered except under the supervision of competent persons.

(4) Guardrails and toeboards shall be installed on all open sides and ends of platforms more than 10 feet above the ground or floor, except needle beam scaffolds and floats (see paragraphs (p) and (w) of this section). Scaffolds 4 feet to 10 feet in height, having a minimum horizontal dimension in either direction of less than 45 inches, shall have standard guardrails installed on all open sides and ends of the platform.

(5) Guardrails shall be 2 × 4 inches, or the equivalent, approximately 42 inches high, with a midrail, when required. Supports shall be at intervals not to exceed 8 feet. Toeboards shall be a minimum of 4 inches in height.

(6) Where persons are required to work or pass under the scaffold, scaffolds shall be provided with a screen between the toeboard and the guard rail, extending along the entire opening, consisting of No. 18 gauge U.S. Standard wire 1/2-inch mesh, or the equivalent.

(7) Scaffolds and their components shall be capable of supporting without failure at least 4 times the maximum intended load.

(8) Any scaffold including accessories such as braces, brackets, trusses, screw legs, ladders, etc. damaged or weakened from any cause shall be immediately repaired or replaced.

(9) All load-carrying timber members of scaffold framing shall be a minimum of 1,500 fiber (Stress Grade) construction grade lumber. All dimensions are nominal sizes as provided in the American Lumber Standards, except that where rough sizes are noted, only rough or undressed lumber of the size specified will satisfy minimum requirements.

(10) All planking shall be Scaffold Grades, or equivalent, as recognized by approved grading rules for the species of wood used. The maximum permissible spans for 2- × 10-inch or wider planks shall be as shown in the following:

Appendix E

Heavy Equipment Safety

Appendix E

Heavy Equipment Safety

Drilling Rig Safety

When working around a drilling rig, several basic safety rules will always apply. A typical drilling rig has rotating equipment, several winch lines, and a 35-ft mast that supports heavy drill pipe. A typical operation includes the use of compressed air of up to 750 cfm at 250 psi.

- Hard hats and safety shoes must always be worn by everyone working in the drilling rig work zone.
- During wire line core or rotary drilling operations, cuttings shall be removed by high velocity air. Safety glasses and leather gloves shall be worn.
- The driller shall perform daily equipment inspections and determine that the drilling rig is in safe operating condition.
- All drill sites shall be cleared through S-300 Plant Engineering for underground and overhead utilities before drilling operations begin.
- The driller's attention shall not be diverted during actual drilling operations.
- Splash protection shall be worn when drilling operations may cause an employee to come in contact with hazardous materials. Auger drilling may minimize this potential. The Safety Officer shall determine the proper procedures if a potential hazard exists.
- The driller shall be responsible for keeping equipment free of fuel and oil leaks.
- When high temperature work is to be done in the field, including arc welding, oxy/acetylene work, or grinding, a hazardous work permit shall be obtained from the LLNL Fire Department.
- The drilling crew is responsible for cleanup of the drill site after well completion.

Pump Truck Operations

The pump truck is generally used for installation and removal of submersible pumps, surge development of wells, and bailing of samples. Two rotating winch lines and a 30-ft telescoping mast are mounted on the 1-ton pump truck.

- Hard hats and safety shoes shall always be worn by everyone working in the pump truck work zone.
- Operator shall perform daily equipment inspections and determine that the equipment is in safe operating condition.
- The operator's attention shall not be diverted during pump truck operations.
- The location of overhead utilities shall be checked before raising mast.

Well Sampling and Water Level Measurements

Sampling of the monitor wells is typically accomplished by an electric submersible pump, an air operated pump, or by bailing a sample. Most electric pumps operate at 220 V ac at 10 to 20 amps. Most of the monitor wells are sampled for VOCs (TCE) or tritium.

- The appropriate gloves shall always be worn when sampling or measuring water levels in monitor wells. A variety of gloves including solvent resistant NBR gloves are available from LLNL Stores.
- Wells should be sampled and water levels measured in order of contaminant level, with the wells with lower levels sampled and measured first.
- Where a potential for splash exists, splash protection shall be worn. LLNL Stores stocks plastic laboratory aprons for limited splash protection. The Site Safety Officer shall determine the level of protection needed on an individual basis.
- When removing well covers from a TCE-contaminated well, allow vapors to ventilate before working on well.

Appendix F

LLNL Site 300 Safety and Operation Procedures

General Safety

Site 300 has several procedures in the *Site 300 Safety and Operational Manual* that must be followed in conducting environmental restoration. This appendix contains the following pertinent procedures.

1-Procedure No. 100	Hazardous Work Permits.
2-Procedure No. 102	Lightning Alerts.
3-Procedure No. 105	Site 300 Traffic and Vehicles.
4-Procedure No. 123	Warning Devices and Signs.
5-Procedure No. 124	Hazardous Operations Status Report.
6-Procedure No. 136	Hiking/Walking off Paved Roads at Site 300.
7-Procedure No. 138	Offroad Travel.
8-Procedure No. 200	General Policies and Controls for the Process Area.
9-Procedure No. 300	B-Division Firing Area Access and Muster Control System.
10-Procedure No. 406	Environmental Procedure for Characterization, Accumulation, and Temporary Storage of Hazardous Wastes in Containers.
11-Procedure No. 501	Firing Range Operations—Building 899.
12-Procedure No. 600	Defense Technologies Engineering Division Facilities.
13-Procedure No. 700	Chemistry Area Operating Procedure, Buildings 825, 826, and 827 Complex.

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 100 9/5/91

HAZARDOUS WORK PERMITS

A. GENERAL

An inspection of the work area to identify and eliminate potential hazards is necessary before construction, maintenance or repair work can be permitted in some areas of the Site. This procedure describes the areas of interest, the hazards of concern and the way to obtain an approved Hazardous Work Permit (Form LL-1986).

B. PERMIT REQUIRED

A Hazardous Work Permit (see Appendix A) is required under the following conditions:

1. Open flame cutting or soldering: Anywhere on Site.
2. Welding (gas or electric): Anywhere on Site.
3. Open fires for any purpose:[1] Anywhere on Site.
4. Cutting of any type on a closed vessel: Anywhere on Site.
5. Using heat-producing (in excess of 228 F/109 C), spark-producing or impact tools: In any explosives work area or explosives storage area.
6. Using electric power tools or powder-actuated tools (e.g., stud guns, etc.): In any explosives work area or explosives storage area.
7. Maintenance or repair work performed by outside contract personnel: In any explosives work area or explosives storage area.
8. Any construction or repair work not under direct control of facility personnel: In any area containing radioactive material or where harmful radiation may be present.
9. When an explosives facility is used to test units containing fissile materials: In any explosives work area or explosives storage area.

[1] Controlled burning of explosives and grass requires special management review and approval and is exempt from this Hazardous Work Permit requirement.

HAZARDOUS WORK PERMITS

C. RESPONSIBILITIES

1. The safety responsibility during construction, maintenance and repairs is shared by the worker, his supervisor and the Facility Supervisor. Hazards Control will review the tasks and the locations to insure that appropriate safety precautions have been taken.

2. The working group must coordinate with the Facility Supervisor in advance. The nature of the work, the hazards of the area and the determination of the need for a work permit shall be made at this time.

3. Issuance of a work permit normally begins with the working group filling out the top portion of the form. Included shall be a description of the tools that contribute to the hazard. Blank forms shall be retained by Crafts Foremen and Facility Supervisors.

4. The Facility Supervisor responsible for the removal of the hazards from the work area and to note this on the work permit.

5. Following review of the area and the work to be performed, Hazards Control shall sign the work permit, post the green copy at the work area and distribute the remaining copies as stated on the permit. Work permits in explosives handling facilities (including equipment rooms and inert areas) are reviewed by the Hazards Control Explosives Safety Group or a designated alternate from the Hazards Control Team. If the bay or cell has multiple entrances, then an "advisory" form of the work permit shall be posted at all personnel entrances to the room. When an entire explosives facility is taken out of service by a work permit, an "advisory" copy of the permit shall be posted on the entrance to each explosives bay or cell in the building. Work permits in nonexplosives facilities are reviewed by the Site 300 Fire Department.

6. When the job is completed, the worker shall sign and date the posted green copy and notify the facility person indicated on the form either personally or by phone. An individual shall remain at the site of a cutting or welding job for a minimum of thirty (30) minutes after the job has been completed for the purpose of extinguishing or reporting any fires that might develop.

HAZARDOUS WORK PERMITS

C. RESPONSIBILITIES - cont'd

7. The Facility Supervisor shall inspect the work area and remove the posted green copy if the job is satisfactory and no new hazard exist. He shall fill out the reverse side of the green copy and make the proper notification to the Hazards Control Office that issued the permit before resuming normal operations. The completed copy (green) shall be returned to the Hazards Control Team Office at Building 871. At the completion of work at explosives buildings, any "advisory" copies shall be returned to the Hazards Control Team Office, Building 871, along with the completed green copy of the work permit.

8. A work permit shall indicate in the upper edge if the entire explosives building is "out of service" and if the explosives hazard is sufficiently removed from the entire building to permit firefighting. The Hazards Control Explosives Safety Office shall only then change the Symbol 1 sign and notify the Fire Department. Notification of the Fire Department and reposting of the Symbol 1 sign shall also be made by Hazards Control when the job is completed and the explosives building returns "to service".

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APPROVED BY: M. L. Grissom
M. L. GRISSOM
Site 300 Resident Manager

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 100 9/5/91

APPENDIX A

HAZARDOUS WORK PERMIT

WORKING GROUP

BUILDING ____ — LLL—HAZARDOUS WORK PERMIT № 5452

ROOM ____ Working Group: ____

Describe Work: ____

Tools or Equip. contributing to Hazard: ____

Est. Start: ____ Est. Completion: ____ Signed: ____

The work described above is complete. I have notified the person indicated → ____

Signed: ____ Date: ____ Notify ____ Ext. ____

FAC. SUPVR.

Remarks: ____

Hazard removed & Permit approved: ____

When work completed and BEFORE resuming normal building activities fill in reverse side of Green Copy. Return to Hazards Control at →

HAZ. CONT.

Remarks: ____

Reviewed by: ____ Hazards Control ____ Ext. ____

GREEN-Work Area; BLUE Fac. Sup.; WHITE-Hazard Control; YELLOW-Working Group
LL-1986 (Rev. 4/70)

☆ 790-509

Lightning Alerts

A. GENERAL

This procedure provides a method for notifying personnel and prescribes the action to be taken to avoid injury from an accidental detonation during a lightning storm. The main body of the procedure is applicable during regular work hours while Section I pertains to off-shift operations. The procedures are based on the use of the Lightning Warning System (LWS) terminals.

B. SCOPE

This procedure supplements the LLNL Health and Safety Manual and applies to all personnel (LLNL, visitor and contractor).

C. HEARING THUNDER OR SEEING LIGHTNING

Anyone hearing thunder or seeing lightning before a lightning alert has been called shall report the information to Hazards Control. The area or facility observing the lightning shall use the *Remote LWS Terminal* . If any potential for lightning exists the area shall be put under area alert until the storm has passed.

D. INITIATING A SITE-WIDE ALERT

When a high potential for lightning exists as indicated either by the LWS in Building 871 or for any other prudent reason, a site-wide lightning alert will normally be called by a member of the Hazards Control Team assigned to Site 300. Anyone who is familiar with the alarm indications of the LWS may call an alert if no Site 300 Hazards Control personnel nor senior members of the Site 300 Manager's staff are available. However, only Hazards Control personnel, the Site 300 Resident Manager or designee may cancel a lightning alert. A high potential for lightning exists when the LWS "ALARM" switch is illuminated RED and the audible alarm sounds. These signals indicate a potential gradient in excess of 1.5 kV/M has existed for one minute on at least one of the monitor stations. The person calling the alert shall immediately inform the Building 871 administrative personnel who will then notify employees that a lightning alert exists.

E. ACTION TO NOTIFY SITE PERSONNEL OF THE ALERT

1. Building 871 Administrative Personnel

   The Building 871 administrative personnel will notify the following individuals/organizations according to a pre-established plan:

   - Protective Force Division (PFD)
   - Site 300 Resident Manager
   - B-Division Representative

     In the event the B-Division control point operator is not available, all B-Division Supervisors or alternates shall be alerted by the Building 871 administrative personnel
   - W-Division
   - Chemistry Facility Supervisor/Chemistry Group Leader
   - Process Area Supervisor
   - Transportation
   - Plant Engineering Operations
   - Maintenance Mechanics
   - Materials Management - Livermore
   - HEAF - Livermore
   - Building 865/ATA/SHARP
   - Hazards Control (if they are not the ones reporting the alert)

2. PFD Control Console Operator

The Control Console Operator (CAS) broadcasts the alarm over the radio network by sounding the radio tone alert twice and then by stating twice "We have been informed that a lightning alert exists". The CAS operator shall request acknowledgment from:

- Process Post (Sierra 43)
- Control Point (Sierra 45) - when manned
- Main Gate (Sierra 47)
- Each PFD Motor Patrol and Escort

3. Process Post

The PFD Officer at the Process Post notifies and receives confirmation from all buildings in the Process Areas and Buildings 825, 826, 827, 828, and 829.

4. B-Division Control Point Operator or secretary

Notifies and receives confirmation from all active explosives work areas, e.g. , Buildings 801. 804, 812, 850 and 851.

5. W-Division Secretary

Notifies and receives confirmation from all active explosive work areas, e.g., Buildings 834, 836, 854 and 858.

F. PROCEDURE DURING A LIGHTNING ALERT -EXPLOSIVES AREAS

1. During an alert, vehicle and pedestrian traffic to any building containing explosives must be approved by the Facility Supervisor. The Facility Supervisor may approve this traffic either because the facility is under area control as described in Appendix A or because the traffic to or from the building is protected, in the event of a lightning related explosion, from fragments, by a barricade, or equivalent

terrain/structure and from blast over pressure that could exceed 2.3 PSI at that location.

2. Vehicles transporting explosives on-site should immediately be driven at least 1250 feet from administrative and non-explosive support areas, parked and left there until the lightning alert has been terminated. Explosives laden vehicles may be parked near explosives storage or operating facilities if intermagazine distance is maintained between the vehicle and a storage magazine and intraline distance maintained between the vehicle and an operating facility. The intermagazine and intraline distances are to be based on the larger of the explosives weights in the vehicle or the facility. If the explosives weights are not known or the driver is unsure of the required intermagazine/intraline distance, the driver shall not park closer than 300 feet to a magazine and 500 feet to an explosives facility. Upon parking the vehicle, the driver shall take shelter in a building that offers protection from fragments and reduces blast over pressure to less than 2.3 PSI. loading or unloading of explosives has started before the alert is received, the operation should continue until a safe termination point is reached.

3. Those explosives operations specified below shall cease immediately or as soon as it is safe to do so and the area evacuated. Only the minimum personnel necessary to safely shut down the operation shall remain at a continuing operation. All other personnel shall evacuate the area and go to a safe location that provides protection from fragments and blast over pressure of 2.3 PSI or greater. Control rooms hardened to 2.3 PSI or facilities at inhabited building distance will provide the required level of protection. When the operation has been brought to a condition in which it is considered safe, the remaining personnel shall evacuate. If a remote LWS terminal is available, the area may go on area control and the work may continue provided that the remote LWS terminal indicates that it is safe to do so. Appendix A describes how to use the remote LWS terminal. The Facility Supervisor will identify those facilities and operations specified below that may target their operations during a lightning alert and determine if their facility must be evacuated during lighting alerts. If so, the safety procedure controlling the operation/facility will identify locations that will provide safe shelter for their personnel.

(a) All operations in and around explosives magazines.

(b) All outdoor operations where explosives are present.

(c) All operations with exposed explosives, bulk electro-static sensitive explosives and/or electroexplosive devices.

(d) All operations in building not equipped with an approved lightning protection system and where explosives are present.

e) All operations in facilities that are within intraline distance of b, c, and d.

4. PFD Officers escorting contract personnel near an explosives facility will seek guidance from the Facility Supervisor as to what safe action to take.

G. PROCEDURE DURING A LIGHTNING ALERT - NON EXPLOSIVE AREA

Although this procedure is primarily intended to provide guidance to personnel working near explosives during the time that a lightning alert has been called, there are other personnel not working with explosives who may also be exposed to danger. These situations are generally associated with people located near tall objects.

1. Anyone located in an observation post or on the drop tower (Building 858) must be evacuated to a control post or other safe areas until the alert is concluded.

2. Plant Engineering supervision shall evaluate the location of their personnel and the risk of being struck by lightning. Outdoor work in elevated locations must be given careful attention.

H. CLEARING THE ALERT

1. The danger of lightning has passed when the potential gradient on all stations has returned to a level below 1.5 kV/M for a fifteen minute period. At this time the "**ALARM**" switch on the Lightning Warning

Lightning Alerts

System console will return to its normal (un-illuminated) color and the audible alarm (if not muted) will silence. When these indications are noted, a person authorized as described in Section D may terminate the lightning alert if he/she determines that another lightning episode is not imminent. If the alert is terminated, he/she will notify the Building 871 administrative personnel of the "All Clear". The administrative personnel and all others in the notification chain will pass the "All Clear" following the same procedure used for calling the alert (Section E).

2. Upon receiving notification that the lightning alert is terminated, the PFD CAS operator shall broadcast the "All Clear" over the radio network by sounding the radio tone alert twice and then by stating twice "The Lightning alert is now concluded".

I. OFF-SHIFT OPERATIONS

1. The lightning warning alarm console "red light" is monitored by the PFD CAS operator. When the red light comes on during off-shift hours, the PFD CAS operator dispatches the Maintenance Mechanics Shift Supervisor or his alternate to Building 871 to evaluate the lightning warning equipment. The Maintenance Mechanics supervisor or his alternate will determine if the alarm is real and informs the PFD CAS operator of his findings. If the Maintenance Mechanics Supervisor or his alternate confirms the lightning alarm is not an equipment malfunction or a false alarm, then a call is made to PFD CAS operator to sound the alert. The PFD CAS notifies all personnel known to be in the explosives areas of the existence of a lightning alert. The lightning warning equipment is monitored by the Maintenance Mechanic Supervisor or his alternate until the lightning system has resumed a no-gradient condition for 15 minutes and then he notifies the PFD CAS operator to conclude the alert.

Lightning Alerts

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Lightning Alerts

APPENDIX A

DETERMINING SAFE CONDITIONS DURING A LIGHTNING ALERT USING THE REMOTE LWS TERMINAL

A. INTRODUCTION

It is possible for conditions to be safe in one areas of Site 300 while a potential for lightning exists in another area. The procedures given here allow a facility supervisor to determine if his facility can be taken off the site wide alert.

USING THE REMOTE LIGHTNING WARNING SYSTEM (LWS) TERMINAL

If a remote LWS terminal is present in a facility, the facility supervisor or designee may administratively direct that work continue if the gradient indicated for the monitor station nearest the facility is below 1.5 kV/M and have been so for 15 minutes. When this action is taken the supervisor or designee shall remain at the terminal until such time as the "All Clear" is given for the site wide alert. If during this time the potential on the monitor station nearest the facility begins to move toward 1.5 kV/M, a lightning alert for the areas will be reinstituted and actions as described in Section F.3 will be taken until the gradient has returned to a level below 1.5 kV/M for 15 minutes or until the site wide "All Clear" is received.

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 103 6/17/91

PROTECTIVE CLOTHING AND FOOTWEAR

A. SCOPE

This procedure describes the policy, eligibility, supervisory responsibility, issue/purchase controls and maintenance of protective clothing and footwear.

*B. POLICY

The Laboratory furnishes protective clothing and footwear as needed.

*C. RESPONSIBILITY

The supervisor is responsible for evaluating the need for protection clothing and footwear, compiling with codes and regulations on protective clothing and footwear, selecting the type of protective clothing and footwear, ensuing that recyclable items are returned to stock and that the protective clothing and footwear are worn as required. Hazards Control will assist the supervisor in determining the type of protective clothing and footwear needed. This includes notifying the supervisor of code requirements.

A system must be established by each department to control and record the issuance of safety shoes. The Health and Safety Manual, Chapter 10, provides guidance on Laboratory policy.

*D. DESCRIPTION AND ISSUANCE PROCEDURE

1. General

Protective clothing for explosives operations is used when the explosive could contaminate personal clothing or cause excessive skin contact. Flame retardant coveralls are required for certain explosives processing operations where the possibility of a flash fire exists. Foul and cold weather clothing may be necessary for extended work assignments in inclement weather. Gloves are necessary when handling solvents and other chemicals with the potential for causing irritation, dermatitis or

*Revised

PROTECTIVE CLOTHING AND FOOTWEAR

*D. DESCRIPTION AND ISSUANCE PROCEDURE - cont'd

*1. General - cont'd

absorbed by the skin. Safety shoes shall be authorized for contamination control when employee work assignments are of such duration that plastic booties are impractical. Safety shoes for foot impact protection will be furnished when deemed appropriate by the supervisor after evaluation of the job assignment. Plastic booties shall be provided at those Site 300 facilities where recommended contamination control is in effect. These booties are to be worn over street shoes by visitors and employees on short duration work assignments when there is low risk of injury from impact. The booties are to be discarded in a contaminated waste can before leaving the contamination control boundary.

Any operation that involves radioactive or toxic material that would generate a dust, fume or mist must be done under controlled conditions. Each operation shall be individually evaluated and protective equipment recommended by Hazards Control.

*a. Protective clothing is stocked by Supply. To obtain garments, submit a Stores Material Order Form (RL-1696) that has been approved by an authorized person listed in the Account Authorization Book. Gloves and booties are available at Supply without authorization.

b. Standard issue coveralls, lab coats, undergarments, socks, etc., are of a cotton fabric. Operators in the Firing Areas and Environmental Test Areas are issued standard issue clothing.

c. Flame retardant coveralls (Nomex fabric) do not have cuffs or metal buttons and are highly resistant to flame. They are of a distinctive eggshell color and are generally issued for use in the Process Area and Chemistry Area.

PROTECTIVE CLOTHING AND FOOTWEAR

D. DESCRIPTION AND ISSUANCE PROCEDURE - cont'd

1. General - cont'd

d. Cold and foul weather clothing is specially purchased through the Purchasing Department after submission of a Purchase Requisition Form (LL-2350-2) authorized by a responsible supervisor. This clothing will be issued to the employee for the duration of his work assignment for on-site use.

e. Gloves are available from the Supply Department. Gloves should be chosen carefully, keeping in mind solvent type, expected duration of exposure and required dexterity. The Industrial Hygiene Group of the Hazards Control Department should be consulted when choosing gloves.

f. Safety shoes are obtained after submittal of a Safety Shoe Authorization Form (LL-4063). Shoes approved for wear in areas where explosives contamination may be present must be non-spark producing. Safety shoes with soles and heels of leather, rubber or synthetic compositions (Neoprene, etc.) and having no exposed nails are acceptable for use. (See Hazards Control for a list of approved styles, if needed.)

E. CARE AND USE OF CLOTHING, GLOVES AND SHOES

1. Protective clothing and shoes issued for explosives operations may be worn into nonexplosive work areas if the clothing is inspected by the wearer for explosives contamination. Contamination should be removed by dusting or wiping before leaving the explosives work area. These clothing and shoes shall never be worn or taken from Site 300 except for off-site explosives operations.

2. Every effort should be made on site to remove radioactive or toxic contamination found on protective clothing and safety shoes. If contamination is found on clothing or shoes, Hazards Control shall be notified.

PROTECTIVE CLOTHING AND FOOTWEAR

E. <u>CARE AND USE OF CLOTHING, GLOVES AND SHOES</u> - cont'd

3. Soiled clothing from Building 827 and all bunker facilities shall be deposited in the containers provided at Buildings 813 and 820. These garments are laundered by an outside contractor and should never be sent off site if contaminated to the point of being an explosives hazard. If the garment is excessively contaminated, it must be decontaminated on site. Special containers are provided at Buildings 813 and 820 for garments in need of repair or replacement.

4. Noncontaminated gloves should be disposed of as normal waste. Gloves should not be reused if they contact chemicals.

5. A contaminated waste material can will be provided for the collection of used booties at each contamination control facility.

REVIEWED BY:

D. A. WETHERELL
Site 300 Supply Department

John Shingleton
J. R. SHINGLETON
Hazards Control Safety
Leader

APPROVED BY:

M. L. Grissom
M. L. GRISSOM
Site 300 Resident Manager

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 105 7/25/90

SITE 300 TRAFFIC AND VEHICLES

A. GENERAL

1. All individuals operating vehicles at Site 300 are responsible to observe the posted speed limits, obey traffic regulations and operate their vehicles safely at all times.

2. Personal and leased vehicles are not allowed in the Limited Area except by special permit approved by the Site 300 Security Representative and the Resident Manager.

3. All LLNL vehicles operating on-site shall be equipped properly and be inspected daily by the responsible operator. If the inspection reveals any defects that will affect the safe operation of the vehicle, it will not be operated until repairs are made. Health and Safety Manual Chapter 35 requires that vehicles be operated in compliance with the California Vehicle Code, both on and off site. If a question arises as to a vehicle's fitness, the Automotive Fleet or Hazards Control Safety Team Leader should be contacted.

4. Seat belts must be worn by the driver and all passengers of LLNL vehicles before the vehicle is put into motion. Vehicles that are not equipped with seat belts should be reported to the Automotive Fleet.

5. All vehicles are subject to search entering and exiting the Site.

6. All on-site vehicle accidents are to be reported to the Protective Service Division for investigation and report preparation.

B. VEHICLE TRAFFIC

1. Emergency vehicles displaying a red light shall have the right-of-way over all traffic.

2. Vehicles carrying explosives shall be given the right-of-way over all traffic, except emergency vehicles displaying a red light.

3. All vehicles approaching an oncoming explosive carrying or emergency vehicle must slow down and keep to the right of the road. In the event two vehicles carrying explosives meet, both should slow down and proceed with caution.

B. VEHICLE TRAFFIC - cont´d

4. Vehicles traveling in the same direction as a vehicle carrying explosives will not approach closer than 50 feet or attempt to pass the vehicle carrying explosives unless signaled to do so by the driver.

5. Vehicles to be passed by a vehicle carrying explosives or by an emergency vehicle are to pull to the right and stop.

6. In case of an accident or fire involving a vehicle carrying explosives, all traffic shall retire to a safe distance and remain until otherwise instructed (see Procedure E under Emergency Section of Site 300 Safety and Operational Manual).

7. Vehicles with wide loads shall be preceded by an escort vehicle displaying a "Wide Load" sign and using a flashing yellow light.

8. All slow moving road maintenance vehicles shall be equipped with the standard "Slow Moving Vehicle" sign and should use a flashing yellow light when operating on the roadways.

C. VEHICLES IN CLOSE PROXIMITY OF MAGAZINES OR MAGAZETTES

A vehicle with the engine running is not permitted within 25 feet of an open magazine unless the vehicle is a fork truck approved for use in the area.

D. VEHICLE ACCIDENTS

1. Driver´s Responsibility

The driver of the vehicle (or his/her designee, if necessary) is responsible for reporting the accident as soon as possible with all information, as follows:

a. For on-site accidents, to the PFD.

b. For off-site accidents involving LLNL vehicles (all vehicles used to conduct official LLNL business), to the local law enforcement agency having jurisdiction and also to the PFD.

c. If the driver is incapacitated and unable to make a report, another employee who is knowledgeable of the details of the accident should do so.

D. <u>VEHICLE ACCIDENTS</u> - cont´d

1. <u>Driver´s Responsibility</u> - cont´d

   d. Report the accident to the driver´s supervisor.

2. <u>Protective Force Division´s Responsibility</u>

   The Protective Force Division (PFD) is responsible for the investigation and documenting of all vehicle accidents occurring on LLNL premises and all vehicle accidents occurring off-site involving LLNL vehicles (all vehicles used to conduct official LLNL business) if not investigated and documented by the local law enforcement agency having jurisdiction. All vehicle accidents will be handled in accordance with existing PFD policies and procedures, which include arrangements with the Automotive Fleet Office for safety inspections and vehicle property damage estimates on LLNL government vehicles.

3. <u>Supervisor´s Responsibility</u>

   The Hazards Control Industrial Safety Group will provide the driver´s supervisor with a copy of the accident report. The supervisor will review the vehicle accident report, determining if the employee was acting within the scope of his job when the accident occurred, then develop and implement any necessary corrective action.

REVIEWED BY: John Shingleton
J. R. SHINGLETON
Hazards Control Safety Team Leader

Wayne J Davis
W. J DAVIS
Site 300 Security Representative

APPROVED BY: M. L. Grissom
M. L. GRISSOM
Site 300 Resident Manager

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LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

*Procedure No. 123 6/8/93

WARNING DEVICES AND SIGNS

This procedure provides information specific to Site 300 operations and is a supplement to the Health and Safety Manual, Chapter 11. Warning devices are not always required. However, when used, they shall conform to the following descriptions:

*A. VISUAL WARNING DEVICES

1. Symbol 1 Signs (Octagonal)

   A Symbol 1 sign is used to designate a building or area which is approved for explosives work. Explosives are not permitted inside a building until it has a Symbol 1 displayed. This sign is to be posted or removed only by Hazards Control.

2. Red Rotating Beacon

   A red rotating beacon indicates a hazardous operation is in progress. Entrance to a building or barricaded area displaying an operating red beacon is STRICTLY PROHIBITED.

3. Amber Rotating Beacon (see also Procedure No. 300, F.1., F.2, and F.3)

   An amber rotating beacon is used to indicate areas where personnel movement in the area is controlled, e.g., Restricted Entry Time (RET) system in the firing area.

4. Magenta Light (Blinking) or Beacon (Rotating)

   A blinking or rotating magenta light indicates radiation within the area. PERSONNEL ARE NOT TO ENTER.

*B. Horn (Intermittent)

1. Pulsed horns are used in firing areas in conjunction with rotating red beacons to warn of an imminent explosion. See Procedure 300, Sections F.1, F.2 and F.3 for proper response to these alarms and warning devices.

*Revised

WARNING DEVICES AND SIGNS

2. Air Horn (Steady)

   An air horn is used as a warning of fire in an explosives work area. Upon hearing the air horn, go to and take shelter in the nearest control room and wait until the "all clear" is announced before leaving.

3. Process Area Siren

   The Process Area has a siren to inform personnel when an emergency exists in the Process Area. It is a warning for personnel to seek safe shelter. See Procedure No. 200 for details of the siren operations.

4. Chime (Pulsed)

   A pulsed chime is used in conjunction with a blinking magenta light as an ionizing radiation warning. Do not enter the area.

5. Gong (Slow)

   A gong is used to warn of a REMOTE operation, e.g., laser in operation capacitor bank charging, etc. Do not enter the building, room or area where the remote operation is being performed.

6. Bell - Continuous (Low Pitched)

   A continuous bell indicates a fire in an area not associated with explosives. Follow directions of emergency personnel.

7. Bell - Continuous (High Pitched)

   A continuous high pitched bell indicates a moving object or equipment malfunction. Follow directions of emergency personnel.

**8. Electric horn, with a warble sound, denotes a remote machine operation is in progress. No access is allowed until approved by the operator and the operation is stopped.

* Revised
**Addition

WARNING DEVICES AND SIGNS

*C. SIGNS

Signs limiting entry to a hazardous area must be obeyed at ALL times. If entry is required, permission may be given by the supervisor or designee of the area at the time entry is desired, provided no hazard is present during the time the area is to be occupied. In case of any questions, contact Hazards Control BEFORE entry is made.

REVIEWED BY: John Shingleton
J. R. SHINGLETON
ES&H Team 5
Operational Safety Division
Hazards Control Department

APPROVED BY:
M. L. GRISSOM
Site 300 Resident Manager

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

*Procedure No. 124 11/9/92

HAZARDOUS OPERATIONS STATUS REPORT

A. INTRODUCTION

1. The Status Report is for use after normal working hours and provides information on possible hazardous operations or conditions which may exist at Site 300. Data for the report is called into the Site 300 administration office before 3:30 p.m. each workday and the report is issued soon thereafter.

2. Any changes in the actual status of a building after this time shall be reported to Hazards Control as soon as possible so appropriate changes may be made in the day's report.

3. The information contained on the status report is considered to be information for "Official Use Only". Care should be taken to assure that distribution is limited only to authorized personnel.

B. SCOPE

1. The status of the building listed on the status report only applies during non-working hours.

C. RESPONSIBILITIES

1. Site 300 Administration Office

   a. Enters facility data, time, date and signs report.

   b. Submits Status Report to the Hazards Control Safety Team Leader or his alternate for completion and approval.

   c. Distributes the report.

* This procedure has been completely revised.

C. RESPONSIBILITIES - cont'd

2. Facility Supervisor

a. Before 3:30 p.m. on each workday, contact the Site 300 administration office (Ext. 3-5245) to report whether or not explosives are present at the facility. The person's initials reporting the status of the facility are listed on the status report.

b. Reports additional information for the remarks column, e.g., overtime, etc., see Appendix A.

NOTE: See Procedure No. 800, Paragraph C, concerning overtime notification.

3. ES&H Team Leader

1. Reports buildings "out of explosives service" due to issuance of a Hazardous Work Permit or for any other reason. These buildings will have their Symbol 1 sign reversed by Hazards Control personnel.

D. TYPICAL HAZARDOUS OPERATIONS STATUS REPORT

1. An example of a typical Hazardous Operations Status Report is attached as Appendix A.

E. SUMMARY

1. Since this report is to be used primarily as a source of information during an emergency, all persons involved in its preparation must exercise care that the information contained is accurate.

2. It is prohibited to bring explosives into a building which has not been properly placarded by Hazards Control through the use of the Symbol 1 sign.

HAZARDOUS OPERATIONS STATUS REPORT

REVIEWED BY: John Shingleton
J. R. SHINGLETON
ES&H Team 5
Operational Safety Division
Hazards Control Department

APPROVED BY: M.L. Grissom
M. L. GRISSOM
Site 300 Resident Manager

APPENDIX A

HAZARDOUS OPERATIONS STATUS REPORT

TIME: ____________ BY: __________ H.C.: ____________________ DATE: __________

BUILDING	INIT.	EXPL.*	REMARKS		BUILDING	INIT.	EXPL.*	REMAR
801 TABLE					834-E			
805					834-F		NE	
806-A					834-G			
806-B					834-H			
807					834-J			
809-A			Co60		834-L			
809-B					834-M			
810-A					836-C			
810-B					836-D			
817-B					840			
817-C					845 TABLE		NE	
817-E					850 TABLE			
817-F					851 TABLE			
818					854-C			
822-C					854-E			
823-B			Co60		854-F			
824					854-H			
825					854-J			
826					854-V			
827-A					855-B			
827-C					855-C			
827-D					857			
827-E					858 TABLE			
828					865		NE	
829								
832-B								
832-D								

MISCELLANEOUS INFORMATION: e.g., overtime, etc. ____________________

____

____

____

____

____

____

* EXPLOSIVES:
√ = EXPLOSIVES FACILITY WITH EXPLOSIVES PRESENT
X = EXPLOSIVES FACILITY WITH NO EXPLOSIVES PRESENT
O = TEMPORARILY OUT OF EXPLOSIVES SERVICE (Symbol 1 reserved)
NE = NON EXPLOSIVES FACILITY (No Symbol 1)

REMARKS:
H = NO ENTRY INTO AREA UNDER ANY CONDITIONS
T = ENTRY INTO ROOM/CELL IN CASE OF EMERGENCY ONLY
FR = TO BE FIRED OR REMOVED
POM = PART ON MACHINE

DISTRIBUTION: Resident Manager (1), Need Manager (1), B-Division (1), MFD (1)
Fire Station II (1), PFD (2), Maint. Mech. (1), W-Division (1)
Hazards Control (1), jce/status report/11-6-92

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 127 6/4/90

SITE 300 SMOKING REGULATIONS

A. GENERAL

Site 300 is an area of extreme fire hazard, particularly during the summer months. Care must be exercised to prevent cigarettes, matches and other sources of ignition from starting grass fires or igniting flammable or explosive materials.

B. SMOKING

Smoking is not permitted in the following areas except as authorized by building operational safety procedures or by a hazardous work permit:

1. On a firing table.
2. Within the confines of any HE Chemistry Area.
3. Within the confines of the Process Area.
4. Within 50 feet of a magazine or other explosives storage area.
5. Within an explosives testing or work area.
6. Within 50 feet of an explosives-carrying vehicle displaying explosives signs.
7. Within any vehicle transporting explosives.
8. In flammable liquid storage areas.
9. In Automotive Fleet´s gasoline pump area.

C. SOURCES OF IGNITION

All personnel are cautioned that matches, cigarette lighters or other fire, flame or spark-producing devices are NOT permitted in any magazine or explosives work area without a hazardous work permit.

REVIEWED BY: John Shingleton
J. R. SHINGLETON
Hazards Control Safety Team Leader

APPROVED BY:
M. L. GRISSOM
Site 300 Resident Manager

Procedure No. 130 2/2/90

WORKING ALONE

*A. POLICY

The following policy statement is taken from the LLNL Health and Safety Manual, Section 26.15:

> "Working alone is defined as the performance of any work function by an individual who is not within hearing or sight range of another individual for more than a few minutes at a time. For hazardous work on exposed, energized electrical equipment, an individual is considered to be working alone if not within sight of someone else. The major danger in working alone is sustaining an illness or injury that precludes self-rescue. No one should perform an operation that might render him incapable of self-rescue without being in contact with another person by voice or other equally effective means. Operations that could be classified as high risk for working alone include:
>
> - work with high-energy materials,
> - work with lasers and related power supplies,
> - work with highly toxic materials,
> - work with high pressure or high vacuum systems,
> - work with cryogenic materials,
> - work with unguarded, high powered, fast moving equipment or machinery,
> - work with exposed, energized electrical systems,
> - work near radiation sources that could cause acute disabling injuries,
> - handling or transferring significant quantities of flammable liquids,
> - work in congested or confined spaces.
>
> Each operation should be reviewed by appropriate management to evaluate the risk of the operation and, where appropriate, ensure that adequate help can be made available quickly in an emergency."

*Revised

B. GUIDELINES FOR EXPLOSIVES OPERATIONS

Many operations involving explosives require two or more persons to be present to accomplish the work safely. In all cases, however, exposure must be limited to the minimum number of personnel required to do the job. For some operations, only one person may be needed. Some guidelines for applying the working alone concept to explosives operations follow:

1. When only one person is needed to safely perform an operation with explosives, a second person shall be at the facility to provide help if needed. The second person need not maintain visual contact with the operator and should not be in the same room, cell or bay with him unless required but the second person must be aware that an explosives operation is being conducted in the facility and make periodic checks on the operator. The use of electronic distress signals which can be activated by the lone operator when he is in trouble and observed by others in the area is highly recommended.

2. When operations involve only the handling or transportation of explosives packaged safely for transfer on-site, only one person need be present at the location if he can safely handle the packages by himself. However, he must notify his supervisor as to his itinerary.

REVIEWED BY: Em. Fawcett
E. M. FAWCETT
Hazards Control Safety Team Leader

APPROVED BY: M.L. Grissom
M. L. GRISSOM
Site 300 Resident Manager

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

*Procedure No. 136 10/7/91

HIKING/WALKING OFF PAVED ROADS AT SITE 300

All personnel and visitors intending to leave paved roads on recreational/nature hikes must adhere to the following rules:

1. Permission to hike off paved roads must be obtained from first line supervision. In the firing areas, permission must be obtained from the Control Point (CP) Operator. Information regarding estimated hiking time and the approximate hiking location must be provided to the supervisor. Upon return to the facility, the hikers must inform their supervisor. If the hikers have been in a firing area, they must also contact the CP Operator.

2. The Protective Force Sergeant must be notified prior to hiking to assure that hikers are not mistaken for intruders.

3. No one is to hike unaccompanied off paved road.

4. Hikers are not to circumvent any safety or security barriers, such as fences, gates or warning signs.

5. Only "Q" cleared (green badge) LLNL employees will be given permission to hike off paved roads.

6. Supervisors must ensure that all hikers are aware of general Site 300 rules and safety regulations, such as Restricted Entry Time (RET) and the hazards which may be encountered near explosives, accelerators or x-ray facilities in the vicinity of the planned hiking route.

REVIEWED BY: John Shingleton
J. R. SHINGLETON
Hazards Control Safety Team Leader

APPROVED BY: M. L. Grissom
M. L. GRISSOM
Site 300 Resident manager

NOTE: THIS PROCEDURE HAS BEEN COMPLETELY REVISED.

OFFICIAL

OFF ROAD TRAVEL

A. Introduction

All personnel, including employees, contractors and visitors who wish to travel in vehicles off-road at Site 300, are responsible to observe the following procedures.

B. General

1.0 Off-road travel at Site 300 is strictly prohibited without permission. All requests to travel off-road at Site 300 anytime, anywhere are to be placed by telephone to Ext. 3-5270 or by radio call sign, Sierra 45. Telephone Ext. 3-5270 rings at both B-Division's East and West Control Points (CP's) and call sign "Sierra 45" is the radio designator for the B-Division Control Points. Each off-road trip must be considered and approved.

2.0 Site 300 is partitioned into "functional" areas to assure that requests to travel off-road are addressed by the supervisor (or alternate) responsible for each area. (See Appendix A). The supervisor (or an alternate) is responsible to determine the operating conditions under which it is safe for off-road travelers to be in their area. Only the responsible supervisor (or alternate), listed in Appendix A can authorize off-road travel in his/her area. **Any approved off-road travel must be confined to the area for which permission is granted.**

3.0 Signs are placed at the intersection of each fire trail with the boundaries defining the "functional" areas. Those signs warn that the area beyond the sign must not be entered without permission.

4.0 Seat belts shall be worn at all times. Depending on the off-road activities, four-wheel drive and/or two-way radios might be required.

C. During Normal Working Hours

1.0 Normal working hours are generally considered to be 0700 to 1530, Monday through Friday.

2.0 The B-Division CP Operator is authorized to consider requests for off-road travel in the two B-Division firing areas only. If the CP Operator grants permission for off-road travel in the B-Division firing areas, he/she shall also indicate clearly that the requester's off-road travel must be confined to the area for which permission is granted.

OFF ROAD TRAVEL

3.0 The B-Division CP Operator shall refer all requests for off-road travel in non B-Division areas to the Protective Force Division (PFD) Central Alarm Station (CAS) Dispatcher. The CAS Dispatcher shall then contact the appropriate individual (Appendix A) regarding the off-road travel request. The CAS Dispatcher then conveys to the requester that permission for off-road travel is either granted or denied.

4.0 Except in rare circumstances, B-Division shall always have a CP Operator on duty during Restricted Entry Time (RET). One exception is extended thermal experiments that may not be concluded by the end of the normal workday. Such experiments can take several days, during which time the firing area remains under muster and no one located in the firing area is allowed to move outside the bunker and no one is allowed to enter the firing area without specific permission from the CP Operator. Under those conditions, the B-Division CP Operator will not be required to remain at the CP during off-hours. The PFD personnel manning the CP during extended thermal experiments shall maintain the firing area lock down (no one in, no one out).

5.0 In the event that the CP Operator is absent during non-RET periods, Ext. 5270 shall transfer to the CAS Dispatcher. The CP Operator shall also have made arrangements for the CAS Dispatcher to answer Sierra 45 radio calls. If the B-Division CP Operator is absent, the CAS Dispatcher then shall contact the appropriate B-Division Supervisor or alternate (Appendix A) to seek permission for off-road travel in the B-Division firing areas. The CAS Dispatcher then conveys to the requester that permission for off-road travel is either granted or denied.

6.0 Requesters are expected to be sufficiently familiar with Site 300 so that they can be allowed unescorted access to the areas they wish to visit. Otherwise, they shall be accompanied by someone who is familiar with Site 300. The CAS Dispatcher shall also have clear, unambiguous communication with the supervisor (or alternate) for the area that is to be accessed. Based on a straightforward "yes" or "no" from the supervisor or alternate (Appendix A), the CAS Dispatcher can then convey permission to travel off-road only in the area in question. If the CAS Dispatcher is not able to contact the supervisor (or alternate), permission for off-road travel is to be denied.

OFF ROAD TRAVEL

D. During Off-Hours

1.0 For the purposes of this procedure, off-hours is generally understood to mean holidays and all other hours outside of the normal workday hours of 0700 to 1530, Monday through Friday.

2.0 All potentially hazardous conditions that exist in any area off-hours shall be clearly described either in the daily Hazardous Operations Status Report or in other written notices from the groups defined in Appendix A. Such instructions must define off-road travel restrictions. If such instructions do not define off-road travel restrictions, the CAS Operator can correctly assume that there is no hazard to off-road travelers in the area during off-hours and can, therefore, grant permission to travel off-road.

OFF ROAD TRAVEL

Reviewed by:

L. R. PAUKERT
Plant Engineering, Site 300
Maintenance Operations
Division Leader

Wayne J. Davis
LT. W. J. DAVIS
Protective Force Division
Watch Commander

John Shingleton
J. R. SHINGLETON
ES&H Team 5
Operational Safety Division
Hazards Control Department

W. Keith Haslam
W. K. HASLAM
Site 300 B-Division Representative

Approved by: M. L. Grissom
M. L. GRISSOM
Site 300 Manager

OFF ROAD TRAVEL

APPENDIX A

Personnel Authorized to Grant Permission for Off-road Travel:

Off-Road Area	Responsible Group	Supervisor/ Alternate(s)	Phone #	Pager
West Firing Area	B-Division	Sator, F.	3-5423	00606
		White, D.	3-5001	07084
East Firing Area	B-Division	Bakker, D.	3-5425	07455
		Gase, V.	3-5356	07456
Small Arms Range	Protective Force	Brandrup, M.	443-1348	
		CAS Operator	3-5222	
		Sergeant's Office	3-5225	
Chemistry/Process *	Chemistry & MFD	Process Post	3-5220	
		Black, W.	3-5203	05180
		Daniels, L	3-5204	05360
		Cummins, B	3-5368	02770
		McCabe, R.	3-5257	02769
Weapons Testing **	Weapons Division	CAS Operator	3-5222	
		Samoian, Ron	3-5236	06153

* All requests for off-road travel in the Chemistry/Process Area shall be handled through the PFD Process Post. Process Post Officers shall contact two people, either W. Black or L. Daniels AND either B. Cummins or R. McCabe for permission to travel off-road in the Chemistry/Process Area.

** Weapons Test Group has given blanket permission for off-road travel in the Weapons Test Area. The CAS Operator is, therefore, authorized by this procedure to grant permission for off-road travel in that area at all times unless specifically directed otherwise in writing.

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General Policies And Controls For The Process Area

A. General

The Process Area is utilized for processing, shipping and receiving of explosives. Processing includes pressing, radiography, machining, inspection and assembly of explosive components to be used in various destructive and nondestructive tests at Site 300. The Process Area is under the administrative of the Mechanical Engineering Department. Buildings 818 and 818-C are under the control of the Materials Management Section. Building 821 is under the control of the Chemistry and Material Science Department.

B. Scope

This procedure and the procedures found in Section 1 of this manual apply to all personnel visiting or working in the Process Area.

C. Operational Control

C.1 Great care shall be exercised to prevent dirt, hand tools, pens, badges and jewelry from falling into processing equipment or explosive powders.

C.2 Explosive operations shall be performed in properly designed buildings designated for the work and with approved Facility Safety Procedures. Personnel who process explosives or are involved in other high potential hazard operations shall follow the Laboratory rules on working alone.

C.3 Flame-producing equipment is not allowed in the area except as permitted by a Hazardous Work Permit (see Procedure No. 100).

C.4 The movement of controlled materials within and to/from the Process Area shall be coordinated with the Site 300 Controlled Materials Group.

C.5 Construction or maintenance work in hazardous areas is subject to the provisions of Procedure No. 100. In addition, specific controls for construction or maintenance work within the Process Area are described in Procedure No. 125.

C.6 Anyone performing work on or at a building must first have the approval of the Facility Supervisor. In the case of work in the general area not pertaining to a building, the appropriate department representative must be contacted.

AREA	DEPARTMENT REPRESENTATIVE	ALTERNATE
Explosives (Process Area)	R. A. McCabe	B. D. Cummins
Bldgs. 818, 818-C & Magazines	M. N. Tandy	C. T. Hachman N. K. Halbert
Bldg. 821 and M-5	W. R. Black	L. C. Daniels K. C. Pederson
Bldg. 809 (Bay 1)	R. A. McCabe	D. M. Zevely
Bldgs. 809 (Bay 2) and 823	G. M. Curnow	J. R. Ambrosino

C.7 Work at M-1, M-2, M-3, M-4, M-5, M-21, M-22, M-23 and M-24 shall be limited to daylight hours or the electrical power to the exterior overhe lights will be turned off manually prior to moving explosives in or out o the building (Reference Waiver Nos. 14-A, 15-A, 16-A and 17-A).

C.8 Before entering the pond area, personnel shall call Building 823 (Ext. 3-5366) and Building 817 (Ext. 3-5261) for permission to enter the pond area. The key is held at the Process Area Post and will not be issued without approval by the area representative.

D. Personnel Controls

D.1 To facilitate tour groups, personnel limits in a bay or cell may be increased to double the posted amount, provided it is approved by the Facility Supervisor and that no operation that puts energy into the explosives is in progress and the increase in the number of personnel meets a programmatic need.

D.2 Personnel entering this area must be checked in and out at the Process Area Post. Personnel not permanently assigned to the area will be announced by the Protective Force Officer (PFO) over the intercom system to the respective facility. All visitors are required to check in with the Facility Supervisor immediately upon arrival. For the convenience an safety of visitors, the status of remote operations in the Process Area shown at the entrance gate.

D.3 All MATCHES, LIGHTERS, and SPARK-PRODUCING INSTRUMENTS shall be surrendered to the police post before entering the Process Area.

D.4 Parking at each facility shall be in designated areas except during the pickup or delivery of material. Explosives are NOT permitted at the 821, 808 or 815 areas.

D.5 Food and beverages are permitted in the Process Area for consumption in the Control Room, offices or other inert areas as designated by building procedures or Facility Supervisors.. Employees shall wash their hands thoroughly before eating.

D.6 Smoking is not allowed in the Process Area except as permitted by each building operating procedure.

D.7 All personnel are required to observe barricades and posted signs. The Process Area Post or Facility Supervisor should be contacted for access to these areas.

D.8 Working Alone

D.8.1 No person shall work alone while performing high risk explosives activities.

D.8.2 When one person is working with explosives in a minimal risk operation, a second person shall be available to provide help if needed.

D.8.3 If visual contact is not maintained, the second person shall be aware of the explosive operation being conducted and make periodic checks on the operator.

D.8.4 The operator working alone shall use a personnel duress alarms in Buildings 806 and 807.

E. Emergencies

A siren is installed near Building 810 to warn employees when an emergency exists in the Process Area. The siren is actuated by the Protective Force Officer at the Process Area Post when instructed by the Protective Force Division's main console (Building 870) that a fire alarm has been received or an emergency exists that requires controlling personnel movements. When the siren is activated, all employees and visitors in the Process Area are to seek shelter in the nearest protected location, as outlined in the various building procedures. When the personnel are under cover, they shall inform the Process Area Post either by MASCO or by phone of their location, badge number(s) and condition. When all personnel have been accounted for, the siren will be silenced. No person shall leave the protected location until given permission by the Process Post Officer, as directed by the Senior Fire Officer or Incident Commander.

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LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 300 4/20/93

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

A. INTRODUCTION

1. General

This procedure shall be used to control access to and movement of personnel within the B-Division firing areas at Site 300 during explosives testing. B-Division will determine when various elements of the procedure are to be activated.

B. SCOPE

This procedure defines the major elements of the system designed and implemented to:

1. Control personnel access to the B-Division firing areas at Site 300 prior to explosives testing;
2. determine the specific location of personnel prior to conducting the test;
3. and to provide additional means of protection should other elements of the protective system fail to perform as intended.

This procedure specifies criteria which must be satisfied in order for experiments to be normally conducted within danger zones of radius 4,000 feet or less. Any experiment requiring a fragment hazard danger zone with a radius larger than 4,000 feet must implement the controls for additional observers as specified in section F.1.a. and/or be controlled by an approved supplemental OSP. The safety regulations in this procedure supplement the LLNL Health and Safety Manual and apply to all test participants, observers, or visitors to the firing area.

C HAZARD ANALYSIS

The most credible hazard addressed by this procedure is the exposure of personnel to blast- or fragment-induced injury or death resulting from a planned explosives test or injury/death resulting from exposure to radiation during accelerator operation.

NOTE: This procedure has been completely revised.

D. RESPONSIBILITIES

1. Supervision

The Site 300 B-Division Representative is responsible for assuring that all work performed in the firing area conforms to this procedure. The Bunker supervisors or their designated alternates shall implement these procedures for work in their respective areas.

References to "Bunker supervisor" in this procedure shall apply either to a designated Bunker supervisor, or to an individual who has been delegated supervisory authority during a bunker operation.

Administrative supervisors of the various groups from which personnel are drawn to accomplish work in the firing areas are responsible to see that their employees are familiar with this and all other applicable procedures governing their work.

2. Employees/Visitors

All employees and visitors are responsible to follow this procedure. When anyone has any questions regarding any aspect of this procedure, they are to check with the Control Point (CP) Operator for guidance.

E. DEFINITIONS

1. Control Point (CP)

The location where personnel access to a firing area is controlled. A CP is located at the main (south) entrance of each of the East and West Firing Areas. The Control Point Operator (CPO) controls personnel access to and movement within the firing areas.

2. Danger Zone

The area around each firing facility which could pose a hazard to exposed personnel during an explosives test. The radius of this zone is established to ensure that no one, either on- or off-site, is exposed to hazardous fragments, debris, firebrands, or blast overpressure (including hazardous impulse noise levels).

3,000 and 4,000 foot radius danger zones have been established for Buildings 801, 850 and 851 (Figures 1 and 2). Buildings 801 and 851 are also surrounded by a fence that establishes a local danger zone. A local danger zone for Building 850 is defined by closure of specific gates on paved roadways.

A fragment hazards analysis (Appendix A) is used to determine the test firing parameters for keeping fragments from Class/Division* 1.1, 1.5 and 1.6, cased explosives within the danger zones. These parameters include the weight of the explosive, case material, case thickness, case inside diameter, case density and calculated maximum case fragment velocity.

When a planned explosives test exceeds any of the fragment hazard firing parameters for a 4000 foot danger zone, a supplemental OSP must be written to specify additional controls (e.g., barricades, shielding, larger danger zones, additional observation points, etc.) that will be implemented to assure personnel protection.

All Class 1.2 explosive's tests will be done on area muster.

The overpressure hazard (Appendix B) is controlled by limiting the impulsive noise exposure to 140 dBA. Appendix B defines the maximum class/division 1.1, 1.5 and 1.6 explosives weights to be, respectively, 104 and 246 pounds for 3000 and 4000 foot radius danger zones. When an area muster explosives test is planned to exceed these limits, controls for additional observers as specified in section F.1.a. shall be implemented or a supplemental OSP is to be written.

All experiments will be shielded to preclude fragments, debris, and firebrands from escaping the danger zone.

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[*] Class/Division definitions are as follows:

1.1	mass detonating
1.2	non-mass detonating, fragment-producing
1.3	mass fire (i.e., propellants)
1.5	very insensitive explosives
1.6	extremely insensitive ammunition

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SY I

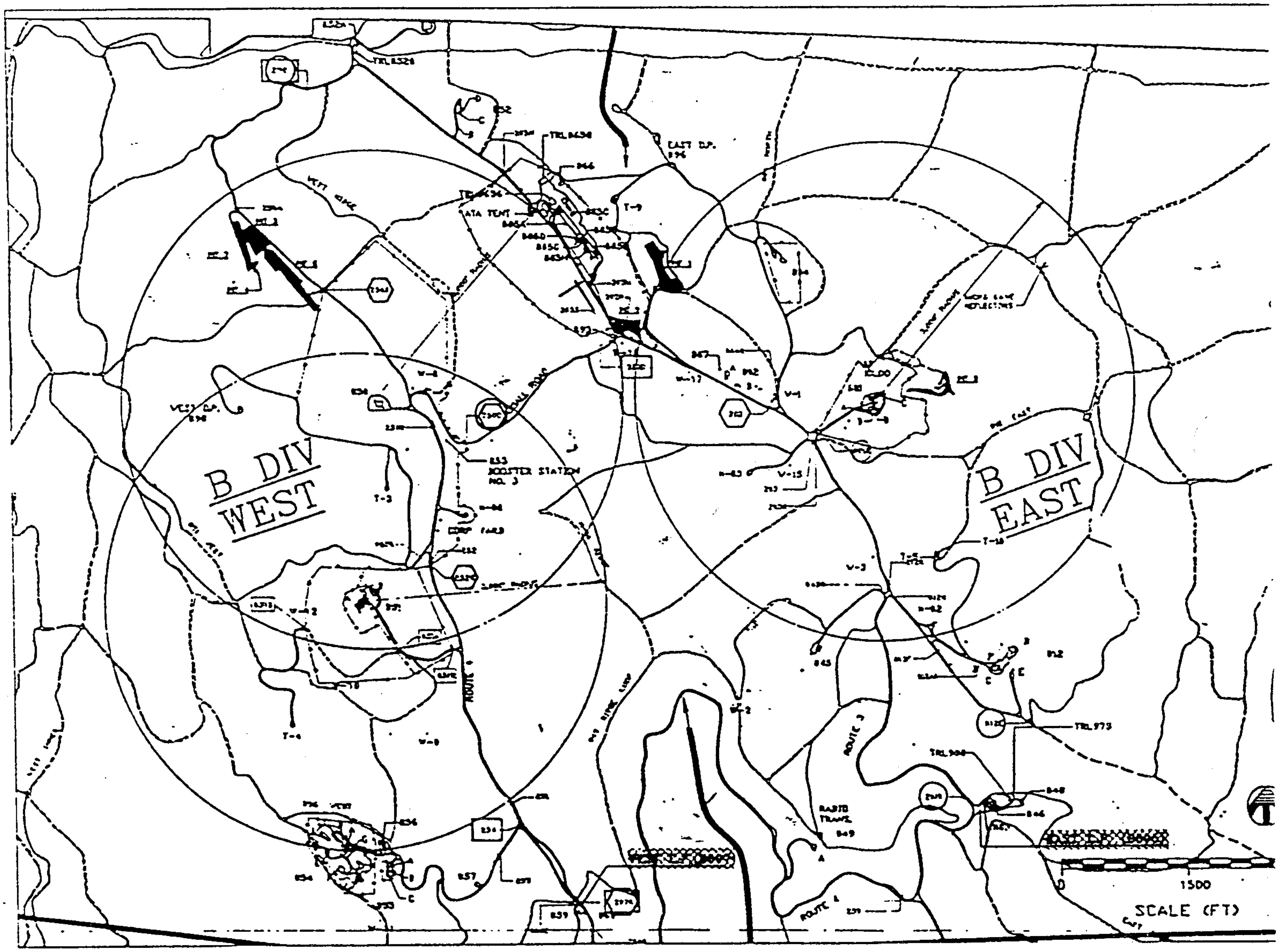

Figure 1: 3000 foot radius danger zones for Buildings 801, 850 and 851

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

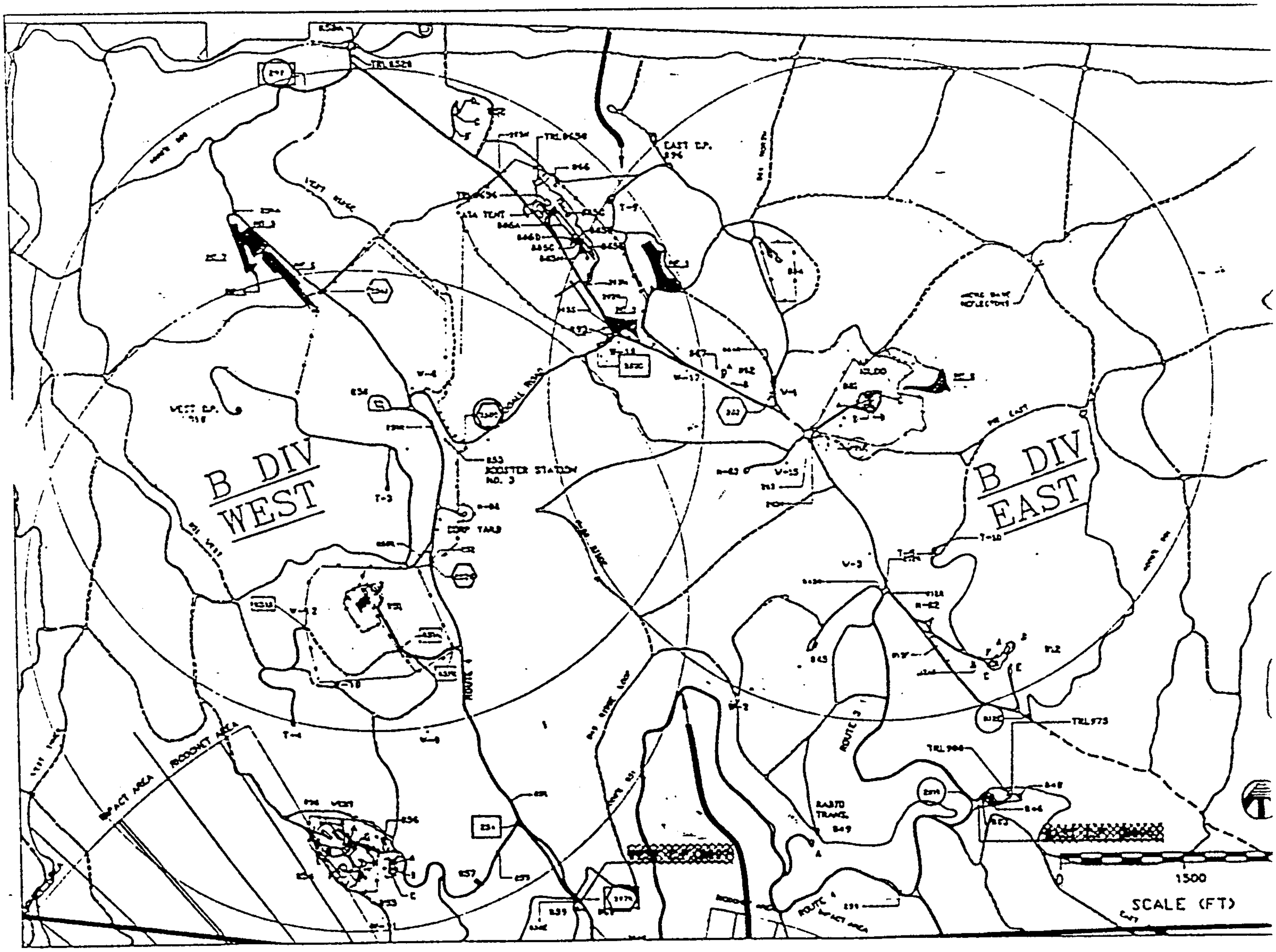

Figure 2: 4000 foot radius danger zones for Buildings 801, 850, and 851

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

3. Firing Areas

There are two areas in the north section of the Site where test firing of explosives are conducted. These areas have been designated as the East and West firing Areas as determined by the closure of specific gates on paved roadways. The East firing Area includes the danger zones for Buildings 801 and 812. (Note that Building 812 is intended for use only on a local muster basis and that the B812 local muster area is defined by specific gate closures rather than by fence line). The West Firing Area includes the danger zones for Buildings 850 and 851. The implementation of a 4,000 foot radius danger zone around each firing facility creates zone overlap such that a well defined boundary between the East and West Firing Areas does not exist (see Figure 2). No east-west overlap occurs with 3000 foot danger zones (see Figure 1).

4. Muster

The accountability of all personnel who have been provided access to the firing area prior to an explosives test. A final count is taken to locate eve individual in the affected area in order to assure that all personnel are ir protected location (generally undercover in a bunker) just prior to the test.

A "local" muster involves accountability of all personnel inside the fenced area of the bunker performing the test. This muster is performed for those tests not presenting a fragment hazard beyond the local bunker fence, nor a noise hazard to the closest bunker access gate or paved Site transportation route. Personnel are required to sign in and out at each bunker and this list is used for the final count.

An "area" muster is called when a hazard extends beyond a local muster area and involves accountability of all personnel in the affected firing area. These personnel have been provided muster badges at the firing area CP on their admittance to the area. The CPO tracks personnel movement within the area and must account for everyone issued a muster badge prior to the test.

5. Observation Posts (OP)

Facilities that are located such that they afford an elevated view of much of the firing areas. Shortly before an explosives test, observers are stationed in the observation post(s) to look for low-flying aircraft and a to be alert for intruders in the firing area (i.e., unauthorized personnel either on foot or in vehicles, livestock, deer or other wildlife).

6. Restricted Entry Time (RET)

The period of time during which personnel access into a firing area is strictly controlled.

F. OPERATIONAL CONTROLS

1. General Considerations

a. Primary and Backup Means of Personnel Protection

The primary means of personnel protection from the hazards associated with explosives testing is the control of access to the firing area and the subsequent muster to assure that all personnel who have been admitted to the area are accurately accounted for prior to conducting the test. In the unlikely event that this primary means of protection fails, a backup system provides adequate warning of an impending test to any individual located in likely areas or locations away from the bunkers (i.e., well sites, pits).

The backup system is comprised of:

(1) network of red, rotating and conspicuous beacons;

(2) a network of loud horns that operate in conjunction with the beacons;

(3) and manned observation posts in the East and West Firing Areas.

The beacons and horns placed at most of the facilities and at other locations throughout the firing areas warn of an impending explosives test. There are locations in the firing area (behind hills, in valleys, etc.) from which the beacons cannot be seen. The wind, weather and working conditions can also diminish the effectiveness of the horns. However, based on tests and assessment by qualified individuals, the horns sounding in conjunction with the beacons are felt to provide adequate warning to anyone within the danger zone at a site where one would normally expect activity (i.e., pits and well sites).

In addition, observers are placed at elevated points to look for aircraft that might be flying too low in disregard for air navigation charts that designate Site 300 airspace as restricted. The observation points are well situated for that purpose during clear weather. However, during foggy or inclement weather when the probability of aircraft intrusion is reduced by severely restricted visibility, the observation posts are not manned. A few minutes prior to conducting an explosives test, the Stockton and Livermore airports are notified so that they can provide additional warning to local air traffic. The observation posts also offer the availability of additional surveillance of the visually unobstructed portions of the firing area.

For experiments for which there is no fragment hazard at 4000 feet, the explosive's weight limit can be increased (see Appendix B) by posting at the site boundaries additional observer(s) equipped with appropriate hearing protection. (Note that there are other explosives weight limits imposed by bunker structural considerations that are not addressed by this procedure). These observers are responsible to visually scan the off-site noise-affected areas and, via radio contact with the CP and/or the bunker, immediately suspend the experiment sequence if unprotected personnel are observed.

b. Restricted Entry Time (RET)

During RET, access to the firing area may be granted, but only with certain stipulations that will permit accurate tracking of and final accounting for all individuals.

RET is normally established in only one of the firing areas at a time. If it becomes necessary to establish RET in both areas on the same day, an additional CP Operator will be assigned so that both CP's are manned.

RET is mandatory for all experiments requiring area musters. RET is not required for local musters (see Section E.4) nor is it required for field radiography or Linac/FXR operation if radiation levels do not exceed permissible levels on the outside of the radiation fenced area (Chapter 33, Health and Safety Manual).

RET is terminated only by the CP Operator at the request of the Bunker supervisor.

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

c. Control Points

Building 897 is the West Control Point (WCP); Building 895 is the East Control Point (ECP). On days that RET is established, the CP Operator is normally on duty a half hour before the start of the bunker crew's normal workday. During RET, the CP Operator will be located at the CP of the area under RET. During normal working hours, the CP can be contacted by telephone (Ext. 3-5270); by radio (call sign "Sierra 45" on channels S_2, B, C, D or "fence watch"); or by personal visit.

During off-shift, weekends and holidays, Ext. 3-5270 and the "Sierra 45" radio calls are answered by the PFD Central Alarm Station (CAS) Operator.

d. Off-Road Travel

Under non-RET conditions, travel on paved roads is not restricted. However, personnel movement anywhere off the paved roads is controlled 24 hours a day, seven days a week, regardless of whether RET is in effect or not. All personnel must obtain permission by telephone (Ext. 3-5270) or by radio (call sign Sierra 45) before leaving a paved road anywhere at Site 300. They must also similarly notify the CP when they have returned to a paved road (see the memo from M. L. Grissom to Distribution, "New Off-Road Travel Requirements for Site 300", dated April 10, 1992). All personnel travel off paved roads during off-hours is controlled by the PFD Central Alarm Station (CAS) Operator (Ext. 3-5270 or Sierra 45).

Off-road travel during the normal workday in either the East or the West firing area is allowed only with permission from either the B-Division CP Operator or from the respective Bunker supervisors who can approve offroad travel only in the areas adjacent to their respective facilities but outside 4000 foot danger zones established for other active facilities.

e. Barricades, fences, etc.

Personnel shall not climb fences or go around gates to enter a closed muster area.

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

f. Visible and Audible Alarms and Appropriate Responses

(1) Road Signs

Lighted signs located on the road leading to the firing areas simply indicate whether a facility is accessible or not. A red light indicates that the facility is inaccessible usually due to either a local or an area muster. A green light indicates that the facility is open, even if RET is established.

Other traffic signs are visible to traffic approaching the CP only during RET.

(2) Rotating (or Flashing) Beacons

A blue rotating beacon at each CP is intended simply as notification that there will be explosives testing or radiographic work conducted in the firing area sometime during the day. Amber rotating beacons located throughout the firing areas indicate that the area is under RET. Red rotating beacons located throughout the firing areas indicate that the area is under muster and that all personnel movement from or between facilities in the firing area is therefore prohibited. Only under special conditions defined by the Bunker supervisor is anyone permitted to leave a facility under muster conditions.

(3) A loud, intermittent horn sounding in conjunction with the red rotating beacons indicates either: 1) that a dry run is in progress, or 2) that final preparations have been made to conduct a test and that a detonation could be imminent. When the intermittent horn sounds, anyone who is unprotected and/or unaccounted for within a local muster area or within the firing area must:

(a) if located within a few yards of a bunker, immediately push the large red button on the nearest arm/run/safe box (doing so will immediately render the firing system incapable of delivering energy to the explosive), or

(b) if located some distance from a bunker, immediately and quickly retreat to the CP (if doing so will not require passing closer to the bunker where the explosive is to be fired). Otherwise quickly retreat as far from the bunker as possible.

(c) If capable of radio contact with the CP, immediately notify the CP Operator of your presence in the firing area.

g. Control of personnel travel in the firing areas under RET (also see Section F.4)

(1) All individuals admitted to a firing area during RET are considered to be potentially at risk of injury and are therefore issued a numbered muster badge and their location noted.

(2) The CP Operator shall be responsible for clearing all personnel movement from one location to another when he/she is satisfied it is safe to do so. The CP Operator has the authority for complete control of all personnel movement in firing areas under RET. Personnel wishing to move from any location within the firing area under RET must obtain permission to do so from the CP Operator.

(3) Personnel arriving at a facility must notify the CP Operator giving name, muster badge number and location. Their name and muster badge number are to be entered on the sign-in board.

(4) After obtaining clearance from the CP Operator to leave a facility, individuals must erase their name and muster badge number from the sign-in board.

(5) If neither telephone nor radio communications are available at the location a person wishes to visit in the firing area, appropriate advance arrangements must be made with the CP Operator so that the individual's location is known at all times. Permission for such a visit might be denied.

(6) If an experiment in Building 801 requires only a 3,000 foot radius danger zone (as defined and enforced by appropriate gate closures), SHARP and ATA personnel can reach their facilities without muster badges by travel through the west area and on DoAll road. They will not be required to muster at shot time.

(7) However, if an experiment in Building 801 requires a 4,000 foot danger zone, ATA and SHARP personnel can reach their facilities only by receiving a muster badge at the east control point and passing through the east firing area. They will be asked to muster in the ATA control room complex in the same manner as any other firing facility.

(8) Personnel may be permitted entry to the firing area via routes other than past the CP if the CP Operator determines it is safe to do so. In this case, numbered badges shall be assigned for each person involved and kept at the CP, but separate from other badges. The CP Operator shall remain aware of the movement of these persons throughout the area and shall n permit any muster to be completed until their location is accounted for. If the CP Operator has any doubts regarding controlling the movement of these persons or if any unsafe condition will result, access to the firing area will be denied.

h. Grass fires

If the Bunker supervisor feels that an explosives test might start a grass fire, the CP Operator shall request a Fire Department Standby at the CP or another appropriate location. The CP Operator may permit movement of Fire Department personnel within the firing area before the "ALL CLEAR" is given, but only <u>after</u> the shot has detonated. However, they <u>must not</u> go beyond the firing facility's local muster gate until the "ALL CLEAR" is given.

i. Fire permissive interlocks

The fire permissive interlock (sometimes referred to as the "pin") is a switch that must be closed in order for an explosive to be fired.

Occasionally, it may not be possible to receive fire permissive interlocks from one of the facilities (broken wire, etc.). If it cannot be readily repaired, the CP Operator may bypass the interlock. The CP Operator must, however, remain in verbal contact with that facility and, in the event of personnel hazard or other serious problems, break the "Fire Permissive Interlock".

If, due to technical difficulties, the testing facility cannot receive the fire permissive from the CP Operator, testing may proceed under the following conditions:

(1) The Bunker supervisor (or his alternate), with approval from the CP Operator, may use a modified "Fire Permissive System".

(2) The testing facility gives the CP Operator a countdown by telephone. The intercom shall not be used except to notify the bunker if the experiment must be delayed for any safety reason.

j. Shift Changes

Normally there will be a period starting at 1600 hours each day when no muster will be started or an existing muster will be broken to allow for shift changes. Such shift changes should be completed as rapidly as possible to allow preparation for testing to resume. In the event that a "cookoff" or similar test is in progress, muster will not be broken until the all-clear is declared by the bunker supervisor and the CP operator.

2. Local Muster Procedures (no RET)

a. General

Explosives tests may be conducted under local muster as long as:

(1) Fragments are not propelled beyond the local muster area boundary, and

(2) overpressure does not exceed 140 dB at the nearest location to the firing table where personnel are normally permitted during local muster conditions (i.e., at the bunker access gate or on the nearest paved roadway outside of the local muster area). The last column of Table 1 (excerpted from Appendix B) is the overpressure guideline to be used by the bunker supervisor (or alternate) to determine whether an experiment can be

considered for local muster. Local muster fragment guidelines are defined by Figures 7-15 of Appendix A of this procedure. The ramrod or experimenter is responsible for conducting a fragment hazard analysis using these guidelines and determining that the local muster criteria in Appendix A can be satisfied. The analysis must be included in the preshot package.

TABLE 1: LOCAL MUSTER GUIDELINE

Building	Distance A* (ft)	Distance B** (ft)	Max. expl. wt. (Class 1.1 or 1.5) (lb)
801	400	875	2.5
850	600	1,500	13
851	450	690	1.2

* This is the distance from the firing table to the nearest local muster boundary (used in fragment calculations).

** This is the distance from the firing table to the paved roadway that is closest to the local muster area boundary (used in overpressure calculations).

Experiments that are expected to produce highly directional effects (i.e., shaped charges) and those producing secondary shrapnel must be shielded to stop all shrapnel that could escape the local muster area.

Before an experiment can be conducted under local muster, it must be reviewed by both of the Bunker supervisors (or their alternates). Both must agree that the experiment is within the Table 1 limits for overpressure and that it is shielded such that secondary fragments will not be propelled beyond the local muster area boundary.

If an experiment does not satisfy these local muster limits/conditions, it must be conducted under RET and area muster with either 3,000 foot or 4,000 foot danger zones.

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

Provision can be made for the option to establish a danger zone larger than the local muster area, but smaller than the 3,000 foot radius danger zone. Controls to accomplish that include, but are not limited to closure of additional gates and appropriate posting of safety roadblocks to prevent unauthorized access to the danger zone. Establishing such a danger zone is subject to review and approval in a single memorandum signed by each of the following individuals or their designated alternates:

Site 300 B-Division Representative
Cognizant Bunker supervisor
Hazards Control Explosives Safety Representative

Every person entering an active facility or intending to work in the area immediately surrounding the facility must sign in upon arrival and must remove his/her name when leaving. The sign-in board is used to conduct the local muster.

b. A local muster is put into effect in the following manner:

(1) The Bunker supervisor (or alternate) will notify the CP Operator who in turn notifies the Protective Force Division. PFD then announces the local muster over the radio net (Security, Plant Engineering Crafts and the Fire Department).

(2) The manual local muster gate will be locked with a padlock or the electric gate will be lowered to barricade the entrance to the facility. Table 2 outlines the gates to be closed for local muster areas.

(3) The red muster light will be turned on and left on for the entire local muster.

(4) The road and local area will be swept for personnel according to a written procedure; all gates will be checked to insure that they are locked or lowered.

(5) A head count of the personnel in the local muster area will be made and verified against the sign-in board.

(6) The warning horn will sound for at least two minutes before firing.

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

TABLE 2: GATES TO BE CLOSED FOR A LOCAL MUSTER

Facility	Gate
801	801-R
812	812-A 234
850	202-D 250-B 252-R
851	851-A 851-B 851-R

c. No one may enter or leave an area under local muster without permission from the Bunker supervisor or his/her designated alternate. After permission has been granted and the person leaves or enters the area, any barricades which had to be moved are to be replaced.

3. Muster for radiography/accelerator testing (no RET)

A sweep of the area and a muster will be conducted to assure that personnel are in a safe place prior to radiography testing on the firing table. The Health and Safety Technicians define and monitor personnel exclusion areas using appropriate instruments.

4. RET Procedures

Any experiment that does not meet the local muster overpressure and fragment guidelines, as defined in Table 1 and Appendix A, respectively, must be conducted under RET or be reviewed for a modified local muster (see Section F.2.a). The Bunker supervisor (or alternate) is responsible to determine whether the experiment meets the overpressure (Appendix B) of 104 and 246 pounds for 3000 and 4000 ft. radius danger zones, respectively. (All HE, including candles and mirror pads, must be considered). The ramrod or the experimenter is responsible for conducting a fragment hazard analysis to determine that the 3000 ft./400 ft. primary fragment guideline defined in Appendix A is satisfied. The bunker supervisor is responsible to assure that appropriate shielding is placed to preclude fragments beyond the danger zone.

appropriate shielding is placed to preclude fragments beyond the danger zone.

An LLNL guideline requires that experiments not produce overpressure exceeding 126 dB in populated areas some distances away the firing area and accounts for local weather conditions as defined by data taken from Site 300 Weather Station balloon-borne telemetry. The temperature and wind velocity data are then used in the LAPS/BLASTO computer codes to specify the maximum weight of explosive that can be detonated and still remain within the 126 dB overpressure guideline.

The technique employing the LAPS/BLASTO computer code and associated weather data is not considered valid over the relatively short distances within the firing areas. Appendix B is the guideline governing overpressure in the firing areas.

a. PFD Preparation for RET

(1) B-Division will notify the PFD as soon as possible the day before if an experiment will require either a 3000 foot or a 4000 foot radius danger zone RET.

(2) In order to minimize the number of people who have to be located, the firing area to be under RET will be locked by the PFD at 0300 and remain locked until the sweep of the area is made immediately prior to beginning RET at 0600. Only those whose assignment requires them to be in the affected firing area between 0300 and 0600 will be permitted entry by the PFD.

(3) Closing and locking the RET gates outlined in Table 3 will preclude paved road access to the respective firing areas.

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

TABLE 3

Gates to be closed to establish RET and during 3000′ and 4000′ area musters. Posts to be manned during area musters.

FACILITY	GATES TO BE LOCKED				POSTS TO BE MANNED
	3,000 ft. Danger Zone		4,000 ft. Danger Zone		
	RET	Additional for Muster	RET	Additional for Muster	
801	202-R	801-R	202-D	801-R	East CP
	201-R	804-R	250-D	265-M	East OP
	812-E	212-R	201-R	804-R	West OP *
	234	812-R	812-E	212-R	
		845-R	234	812-R	
			265-N	845-R	
850	292	250-R	297-R	252-R	West CP
	250-A	252-R	254	265-M	West OP
	202-D	850-R	202	851-R	
	297		265-N	850-R	
	254		250-A	250-R	
851	292	250-R	292	258	West CP
	250-A	252	250-A	250-R	West OP
	202-D	850-R	202-D	252-R	
	254	851-R	254	850-R	
	297-R		297-R	851-R	

* At the Bunker supervisor's discretion

b. RET Established by PFD Personnel

(1) PFD owl shift personnel will usually establish RET by dispatching two officers (PFO's) to the CP at about 0600 hours. From the outset of the days in which RET is put into effect, checklists are to be used in the operation of the CP.

(2) In order to notify approaching traffic of RET control, the thre road signs near the affected CP are rotated into the visible position.

(3) One Control Point Protective Force Officer (CPPFO) remains at the CP to make certain that all remotely operated gates indicate closed on the CP console. All other gates that were locked at 0300 are to remain closed during the sweep described below.

(4) After signing in and receiving a muster badge, the second Motor Patrol (MP) PFO is to immediately visually assure that all remote and manual gates defining the firing area are closed (RET Gates, Table 3).

(5) The MPPFO begins a "sweep" (defined by the PFD for each firing area) to assure that the firing area is clear of all personnel. No one is to be permitted into the firing area during the sweep. If people are located in the sweep, the MPPFO is to inform them of the need to return to the CP to sign in and receive a muster badge. The MPPFO is to contact the CPPFO regarding individual(s) returning to the CP to be signed in. <u>Muster badges are not to be carried on the sweep</u>.

(6) The sweeps are to be conducted such that <u>all</u> paved roads in the firing area are checked. Under weather conditions that will permit reasonable off-road travel, the MPPFO is also to check other likely areas, such as well sites and burial pits that are not visible from the paved roads.

(7) Once the sweep is completed, two PFD personnel remain at the CP. One PFO is to remain close to the telephone, radio and console controls to operate the remote CP gate and to place magnetic buttons on the map defining individuals who have been granted access to the firing area.

(8) The other PFO is to control access to the firing area in this way:

(a) Any special conditions of entry will be well-defined by B-Division.

(b) Unless special conditions of entry have been imposed, the current safety training record is the only criterion used to determine a person's eligibility to enter the firing area (see Section G).

(c) If the record indicates that training is current <u>and</u> the person meets other special conditions of entry, the PFO is to record the person's name, intended destination, entry time and training status. If training is not current, but an authorized Safety Escort is available, also record the name of the escort.

(d) If the individual's training is not current and they are not accompanied by an authorized safety escort, deny entry to the firing area.

(e) If all is in order, issue the muster badge, permit the individual to enter the area and place a magnetic marker representing the individual on the map .

c. RET from Arrival of B-Division CP Operator Until RET Conclusion

(1) On RET days, the B-Division CP Operator will arrive at the CP a half hour before the start of a normal bunker work day anc will be briefed by the CPPFO regarding the status of RET.

(2) As soon as the status is well-defined and clearly understood (including exact badge count correlation with the magnetic map) to the mutual satisfaction of the CPPFO and the B-Division CP Operator, the CP operator then assumes responsibility for the RET and operation of the CP.

(3) For the duration of the RET, the CP Operator is to remain close to the console, map, telephones, intercom and radios.

(4) In order to minimize confusion, the console area of the CP is generally off-limits to all personnel except the CP Operator and the assisting PFO.

(5) Continuous PFO support at the CP is to be assigned until RET is concluded. That PFO assignment includes the following:

(a) Check of each individual for proper training using the current, alphabetized training record. (Unless special circumstances require that access be restricted to specif individuals or groups of people, current training is th only necessary condition for access. Note that untrained people may enter the firing area, but only if they are accompanied by an authorized Safety Escort (see Section G).

(b) If training is current and special entry conditions have not been imposed, access to the firing area is granted after issuing a muster badge and recording the following information: name, muster badge number, destination, entry time and a notation regarding training.

(c) Clearly communicate with the CP Operator regarding any condition that affects safety and generally assist in the CP operation.

(d) Retrieve muster badges of individuals leaving the firing area prior to the conclusion of the RET and record exit time.

d. Operation of the Observation Post

The following are general guidelines that can be modified for unusual experiments when approved by the Site 300 B-Division Representative (or his designated alternate).

Under normal conditions, the West OP is manned for area muster shots in the west area. Likewise, the East OP is manned for area muster shots in the east area. However, at the discretion of the East area supervisor, the West OP might also be manned to afford additional observation of the B801 area. In concurrence with the Bunker supervisor and the CP Operator, the Site 300 B-Division Representative shall determine the necessity of manning the Observation Posts (OP) in inclement weather (fog, etc.). When the OP is not manned due to foggy conditions, the CP Operator shall contact the Stockton Tower by telephone about ten minutes prior to any firing to determine if any aircraft are present in the area of potential hazard.

During a lightning alert, the experiment is delayed and personnel manning the Observation Post must be evacuated to the Control Point or other safe area until the lightning alert is called off.

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

The following points describe main elements of the operation of the OP:

(1) A few minutes before the bunker calls for muster and head count, the CP Operator requests the PFD to man the observation post. At the discretion of the Building 801 Supervisor, both East and West OP's are to be manned for the East Firing Area shots.

(2) En route to the OP, the PFO scans the area for intruders or anyone else who might inadvertently be anywhere within the firing area. In the event that someone is spotted, the PFO is to immediately notify the CP, check with the personnel sighted, and then escort them out of the area.

(3) Upon arrival at the OP, the PFO is to verify that the telephone, the MASCO intercom, and the radio (hand-held and base station) provide good communication with the CP. If any one of these three means of communication is unsatisfactory, the PFO is to make certain that the CP Operator has a clear understanding of the deficiency and that the remaining communication is still reliable. Presently, there is no intercom capability or fire permissive capability between the west OP and the east Firing Area. Therefore, communication between the West OP and east firing facilities is most reliably accomplished by telephone.

(4) At this point in the sequence the muster headcount is finalized.

(5) After the muster is successfully conducted, the PFO activates the fire permissive switch when the CP Operator requests it.

(6) During the final few minutes prior to a test, the PFO is to be alert for low flying aircraft and any other unauthorized entry into the firing area, including pedestrians or vehicles. If there is any indication of unauthorized entry into the firing area, the PFO is to <u>IMMEDIATELY</u> deactivate the fire permissive switch ("pull the pin") and then notify the CP of that action.

(7) After the experiment is conducted, the PFO informs the CP c shot plume travel and other general conditions (fires, etc.) on or near the firing table.

(8) The fire permissive is deactivated when requested by the CP.

(9) The PFO is not to leave the OP until the CP issues the "all clear".

5. Muster Procedures

a. General

A muster is necessary before any hazardous test is conducted. The Bunker supervisor is responsible to declare the type of muster to be called: a local, a "modified" local or an area muster.

The Bunker supervisor decides when the muster shall be called. When possible, all facilities in the area should be alerted fifteen (15) minutes in advance of an impending muster.

b. Muster Sequence

(1) Personnel at all facilities or locations in the firing area will either have been asked to leave the danger zone or the firing area, or they will have been asked to go under approved cover. The Bunker supervisor or designate requests the muster and gives the CP operator the bunker head count. Other facilities or locations similarly report respective head counts to the CP operator.

(2) ONCE THE MUSTER HAS STARTED AND UNTIL THE "ALL CLEAR" IS GIVEN, NO ONE WILL BE ALLOWED TO MOVE ABOUT WITHIN THE DANGER ZONE WITHOUT THE EXPLICIT PERMISSION OF THE BUNKER SUPERVISOR WHO REQUESTED THE MUSTER. PERSONNEL MOVEMENT WITHIN THE FIRING AREA, BUT OUTSIDE THE DANGER ZONE, SHALL BE AT THE DISCRETION OF THE CONTROL POINT OPERATOR.

(3) The CP Operator will then notify all facilities involved if the muster is accurate and that all personnel are accounted for.

(4) With assistance from the PFO remaining at the CP, the CP operator verifies that the bunker head count correlates exactly with the badge rack, with the sign-in log and with the magnetic map . Once all locations and respective headcounts are well defined, the PFO is dispatched to the OP. The CP Operator will

not verify the final muster head count until the OP is manned and the OP communication systems are checked.

(5) The CP Operator will grant the fire permissive only when he/she is completely satisfied that all personnel are properly accounted for and that they are either under approved cover or outside of the danger zone.

(6) The CP Operator must remain continually alert for any communication regarding the possibility of any unauthorized entry into the firing area and be prepared to immediately deactivate the fire permissive.

(7) When a muster is underway, all PFO's and operations personnel assigned to the firing area are to be continuously alert for low-flying aircraft and any other unauthorized movement of personnel or vehicles or livestock until the "ALL CLEAR" is received. The CP Operator shall immediately be notified if a potentially dangerous situation develops and shall immediately delay firing until a safe situation has been re-established.

(8) The Bunker supervisor is to ensure that the CP Operator and PFO manning the observation post are kept informed regarding status and the estimated time that the test is to be conducted.

c. Other Considerations

(1) Post-Test Activities

The CP Operator shall keep the Bunker supervisor informed regarding shot plumes and fires. After an explosives test, the Bunker supervisor or his designee shall inspect the firing table as soon as the shot plume has dissipated. If there is no evidence of a malfunction in the test, the Bunker supervisor or designee shall give the CP Operator the "ALL CLEAR". The CP Operator shall announce the "ALL CLEAR" to all other facilities in the RET area. Confirmation of the "ALL CLEAR" shall be given by breaking the permissive interlock at each facility. The CP Operator shall check to see that all permissi interlocks are broken. If the testing facility reports a malfunction, appropriate procedures shall be followed immediately. (See Procedure No. 301.) The Bunker supervisor will also notify the CP Operator when RET is to be discontinued.

(2) Concurrent Testing

If two or more facilities have completed their preparations and wish to test under the same muster, they may do so provided that the CP Operator and all active participants agree. They must also agree upon the order in which the tests are to be conducted.

The CP Operator must notify all manned facilities in the area of the number of tests and the order in which they will be conducted. After each test has been completed, the CP Operator shall break the fire permissive, notify all facilities of the test completion, advise them of tests still to be completed under the same muster and ask them to leave the fire permissive switch on. The CP Operator and the OP personnel shall survey the firing area for hazards and, if it is clear, they will give the "Fire Permissive Interlock" to the next facility in the agreed upon order.

Facilities that have completed their test and are in the danger zone shall remain undercover and not inspect their firing table or test cell until all tests have been completed. After all participating facilities have given the "ALL CLEAR", the CP Operator shall announce the final "ALL CLEAR" and the end of the muster. Where a special need exists (picking up film cassettes, etc.), a Bunker supervisor or his alternate may be allowed to inspect his table after firing and before the pin is given to the next testing facility. All participating Bunker supervisors and CP Operators must agree to such arrangements in advance.

(3) Off-Hours Testing

For tests being conducted during off-hours (after 1600 hours, weekends, holidays, etc.), there is no deviation, either in manpower required to do the work or in the procedures, from the above described procedures for RET and for area and local musters.

(4) Classified Assemblies or Explosives on the Firing Table During Off-Shift

If necessary, a classified assembly or explosive may be left on the firing table during off-shift hours under the following conditions:

(a) The Firing Bunker supervisor or designated alternate shall advise the B-Division Representative (or designated alternate) and notify the CP Operator, the Maintenance Mechanics Supervisor and the Protective Force Division.

(b) The blue rotating beacon at the CP is to remain in operation and all appropriate warning signs must be displayed at all entrances to the firing table.

(c) The Firing Bunker supervisor or designated alternate must also arrange with Security to maintain proper surveillance until the bunker crew returns to duty. LLNL Form Number LL-5252, "Site 300 Classified Assembly Standby Information", will be completed and reviewed with the PFD Duty Sergeant and/or the PFO performing the standby and the Maintenance Mechanic Representative. One copy of this form is left at the bunker for shift change information for the PFD and the Maintenance Mechanics; one copy is kept by the Bunker supervisor; additional copies are distributed to individuals listed on Form LL-5252 as soon as possible.

(d) The Bunker supervisor or designated alternate is responsible for seeing that arrangements are made to satisfy both safety and security requirements prior to his leaving the Site.

(5) Dry Runs

If explosives are present, but there are no electrical connections to the detonator(s), all dry runs can be conducted using a local muster. However, if electrical connections have been made t the detonators (regardless of whether the det cables are locke into the grounding panel), the dry run muster must be conducted the same as for the actual experiment.

G. TRAINING

HS-95 is required for all individuals who wish to enter Site 300. A section of HS-95 defines an individual's responsibilities under RET and is required as a condition of unescorted entry to the firing area. During RET, anyone who has not received HS-95 training, but who still needs access to the firing area during RET, must be accompanied into the firing area by a B-Division-approved Safety Escort. A current list of all HS-95 trained individuals and a current list of all individuals authorized to act as Safety Escorts are maintained at the CP.

Personnel from PFD/Site 300 prepare for and establish RET and also operate the observation posts. Each individual performing those duties must have received formal, B-Division-defined training addressing those aspects.

All principal CP Operators must also have received formal, specific training in CP operations.

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

REVIEWED BY: W. Kent Haslam

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Site 300 B-Division Representative

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W. J. DAVIS
Protective Force Division

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for M. R. ANASTASIO
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APPROVED BY: M.L. Grissom

M. L. GRISSOM
Site 300 Resident Manager

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 300

4/20/93

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

APPENDIX A

FRAGMENT HAZARD CALCULATIONS

Interdepartmental letterhead

Mail Station L-281

Ext: 28403

January 27, 1993

FEB 24 3 [illegible] PM '93

To: Kent Haslam

From: John Pastrnak & Joe Baker

Subject: Refined Fragment Hazard Calculations for the Site 300 Firing Areas. (END93-008)

Improved calculations have been performed for B Division open air firing facilities to replace the fragment hazard section of the previously published guidelines[1,2,3] for cased explosive charges. The new refined calculations significantly relax the previous limitations associated with keeping primary fragments within the various hazard zones defined by a circular boundary of specific radius from each shot table.
The present radii and associated Hazard Zones are identified as:

4000 feet: normal Area Muster
3000 feet: reduced Area Muster
400 feet: B801 Local Muster
450 feet: B851 Local Muster
600 feet: B850 Local Muster

For each of the hazard zones identified above, a family of 3 data plots are provided in the following formats:

1. case thickness vs. case initial velocity
2. case areal density vs. case inital velocity
3. case thickness vs. case inside diameter

Due to the bounding nature of the calculational technique, all of the results are believed to err on the conservative side by definition. This is especially true for the thickness vs. diameter plots which are based on the conservative Gurney equation.

The following 15 figures can be used as guidance in determining whether additional controls (for example; local shielding) are required to prevent case fragments from leaving the hazard zone. For a given case material and hazard zone, any combination of case thickness and (charge inside diameter or known-case velocity) that lie above each curve are fragment producing combinations that would require additional controls or review to prevent fragments from leaving the hazard zone. Conversely, combinations of case thickness and (charge diameter or known case velocity) on or below each curve would not require any additional controls.

University of California
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John Pastrnak
Nuclear Explosives Engineering Division

C.F. Baker

C. F. (Joe) Baker
Mechanical Engineering Department

Distribution

Anastasio, M.	L-035
Baker, J.	L-871
Bakker, D.	L-801
Breithaupt, D.	L-035
Chase, J.	L-281
Copeland, A.	L-122
Draney, E.	L-038
Grace, P.	L-871
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Janzen, J.	L-035
Jones, R.	L-035
Klieber, J.	L-871
Lane, J.	L-871
Multhauf, L.	L-035
Pastmak, J.	L-281
Prokosch, D.	L-283
Rubke, J.	L-874
Sator, F.	L-851
Shingleton, J.	L-871
Simmons, L.	L-801
Smith, D.	L-038
West, J.	L-122
Wood, C.	L-035

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[1] Baker, J. & Pastmak, J., Blast and Fragment calculations for the S300 Firing Areas, LLNL Internal memo to K. Haslam, May 11, 1992

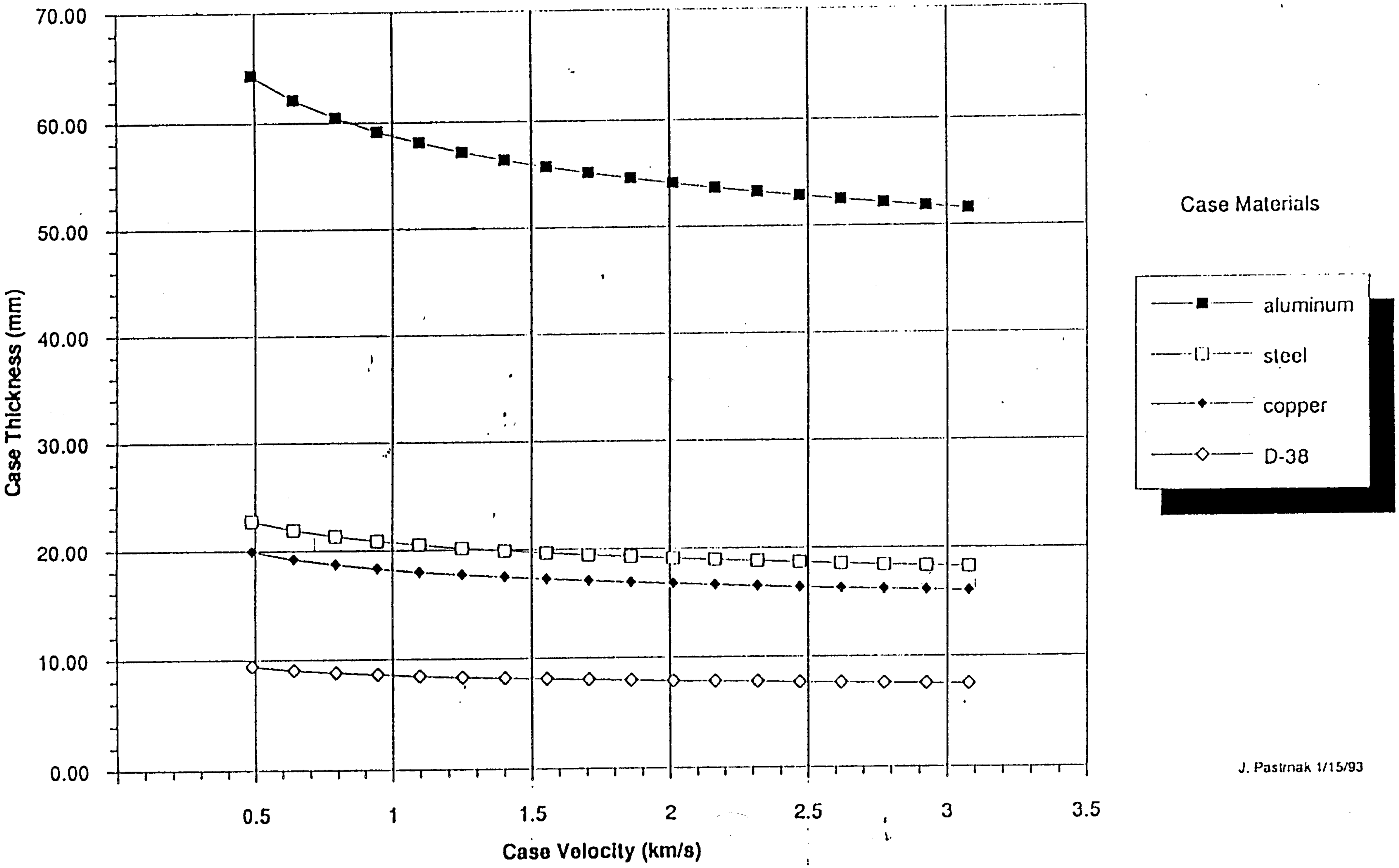
[2] Baker, J. & Pastmak, J., Additional Blast and Fragment calculations for the S300 Firing Areas, LLNL Internal memo to K. Haslam, October 23, 1992

[3] Baker J., Pastmak, J., Revised Site 300 local muster area blast and fragment hazard calculations for buildings 801, 850, and 851 , LLNL Internal memo to K. Haslam, April 6, 1992.

Figure 1

Case thickness vs. case radial velocity to keep primary fragments from un-shielded shots within a radius of 4000 feet

(combinations of case thickness and inside diameter above each material curve result in fragments that travel more than 4000 ft.)



J. Pastrnak 1/15/93

Figure 2

Case areal density vs. case radial velocity to keep primary fragments from un-shielded shots within a radius of 4000 feet

(combinations of areal density and velocity above the curve result in fragments that travel more than 4000 ft.)

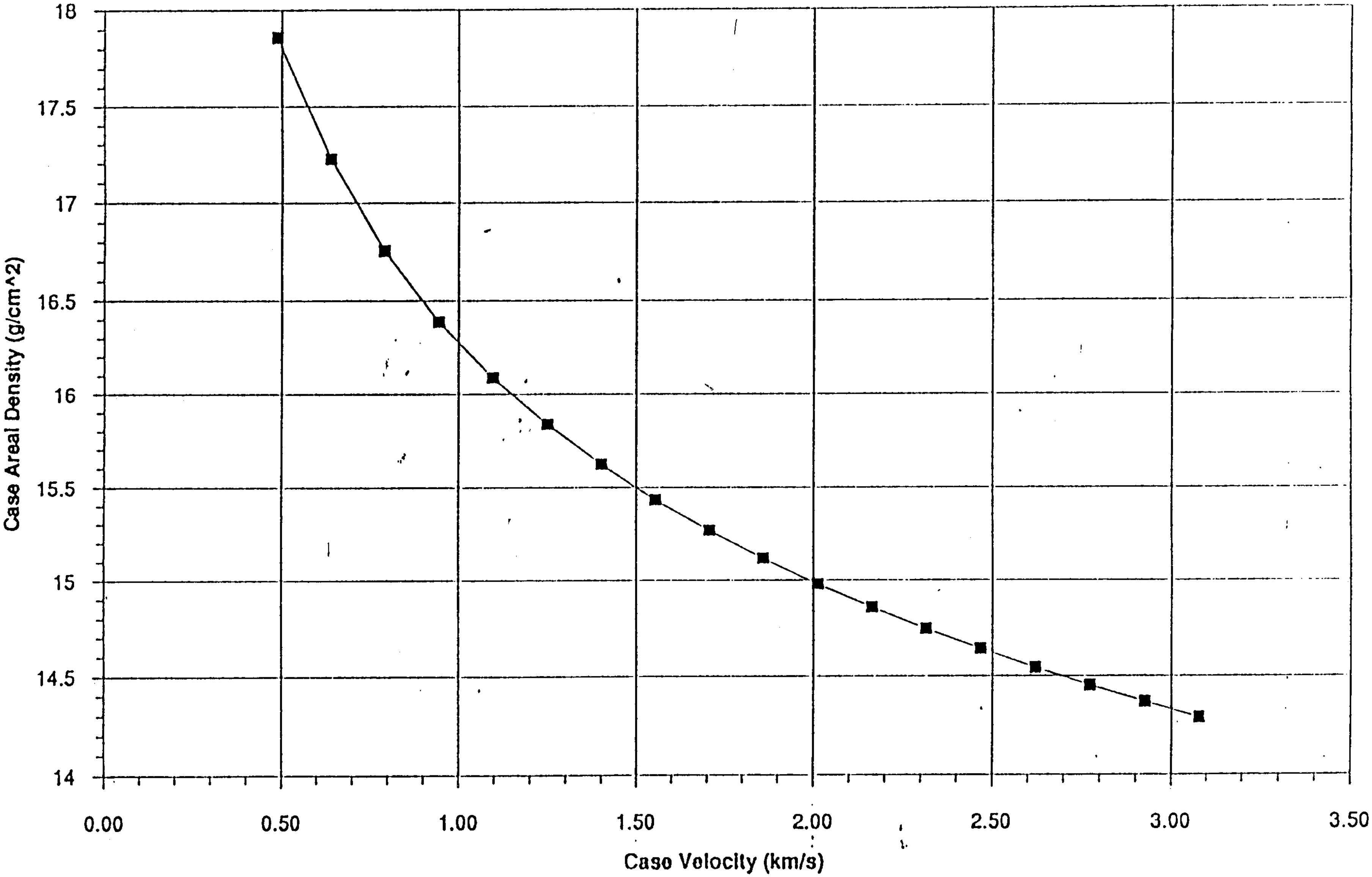
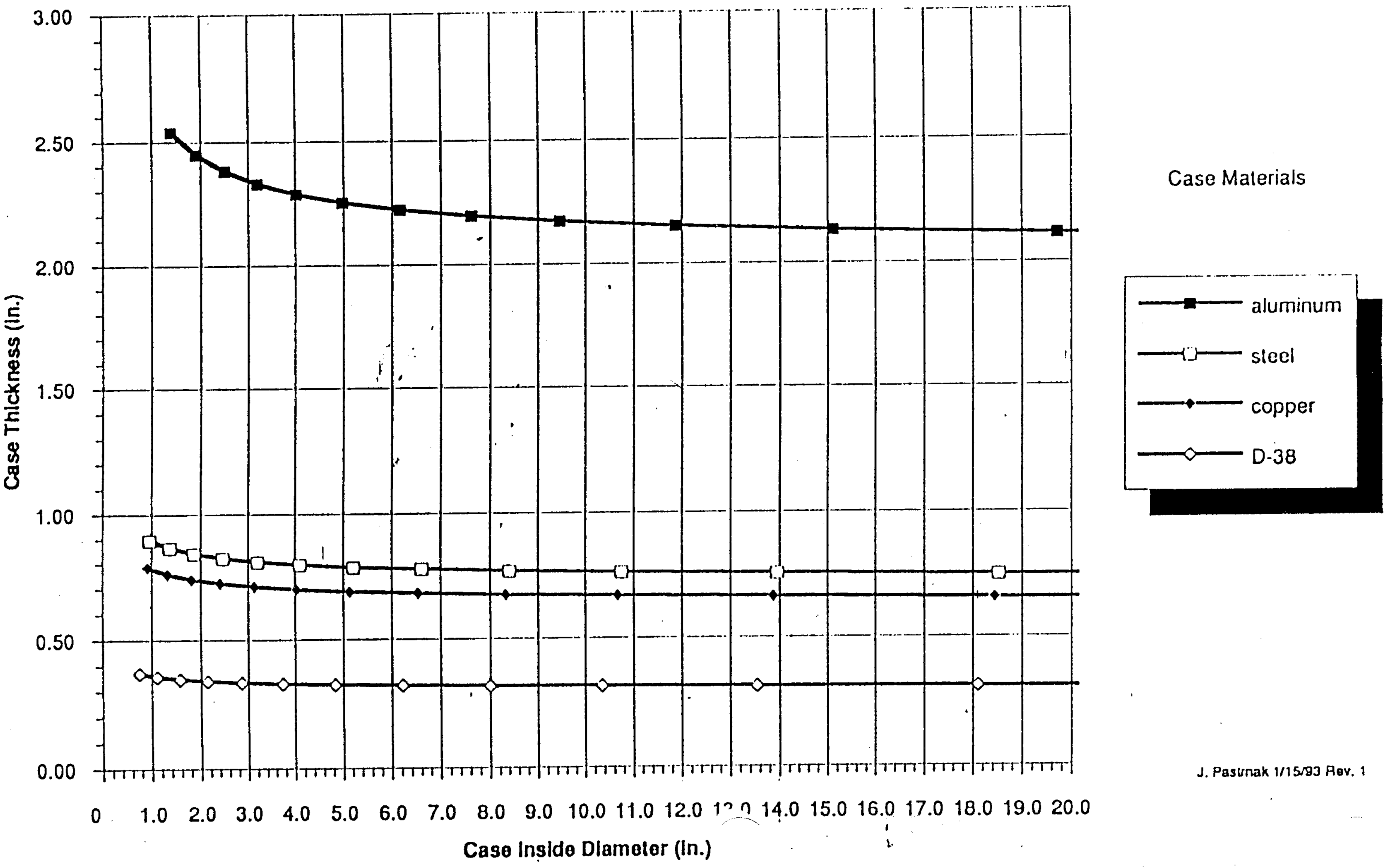


Figure 3

Case thickness vs. case inside diameter to keep primary fragments from un-shielded shots within a radius of 4000 feet

(combinations of case thickness and inside diameter above each material curve result in fragments that travel more than 4000 ft.)

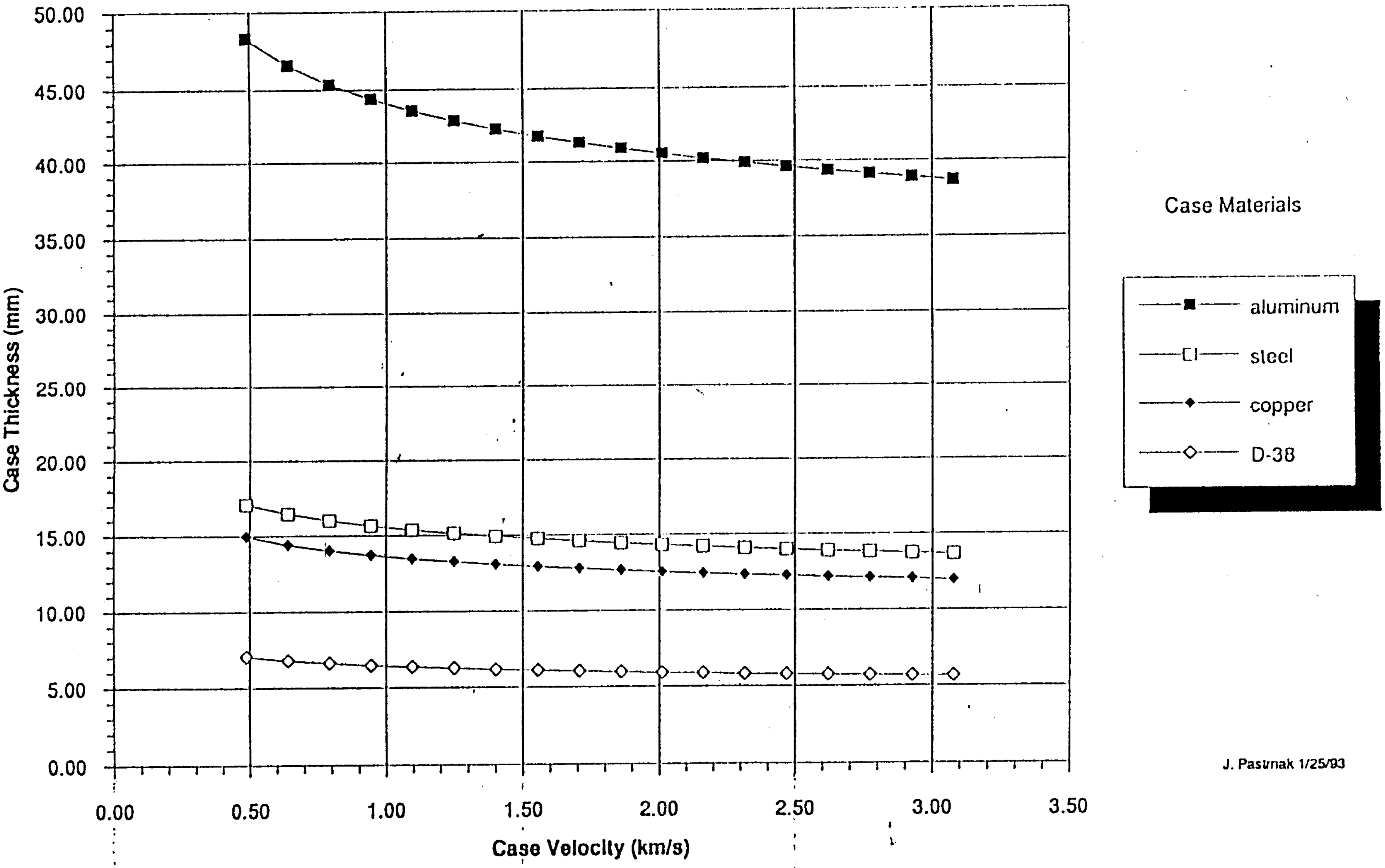


J. Pastrnak 1/15/93 Rev. 1

Figure 4

Case thickness vs. case radial velocity to keep primary fragments from un-shielded shots within a radius of 3000 feet

(combinations of case thickness and inside diameter above each material curve result in fragments that travel more than 3000 ft.)



J. Pastnak 1/25/93

Figure 5

Case areal density vs. case radial velocity to keep primary fragments from un-shielded shots within a radius of 3000 feet

(combinations of areal density and velocity above the curve result in fragments that travel more than 3000 ft.)

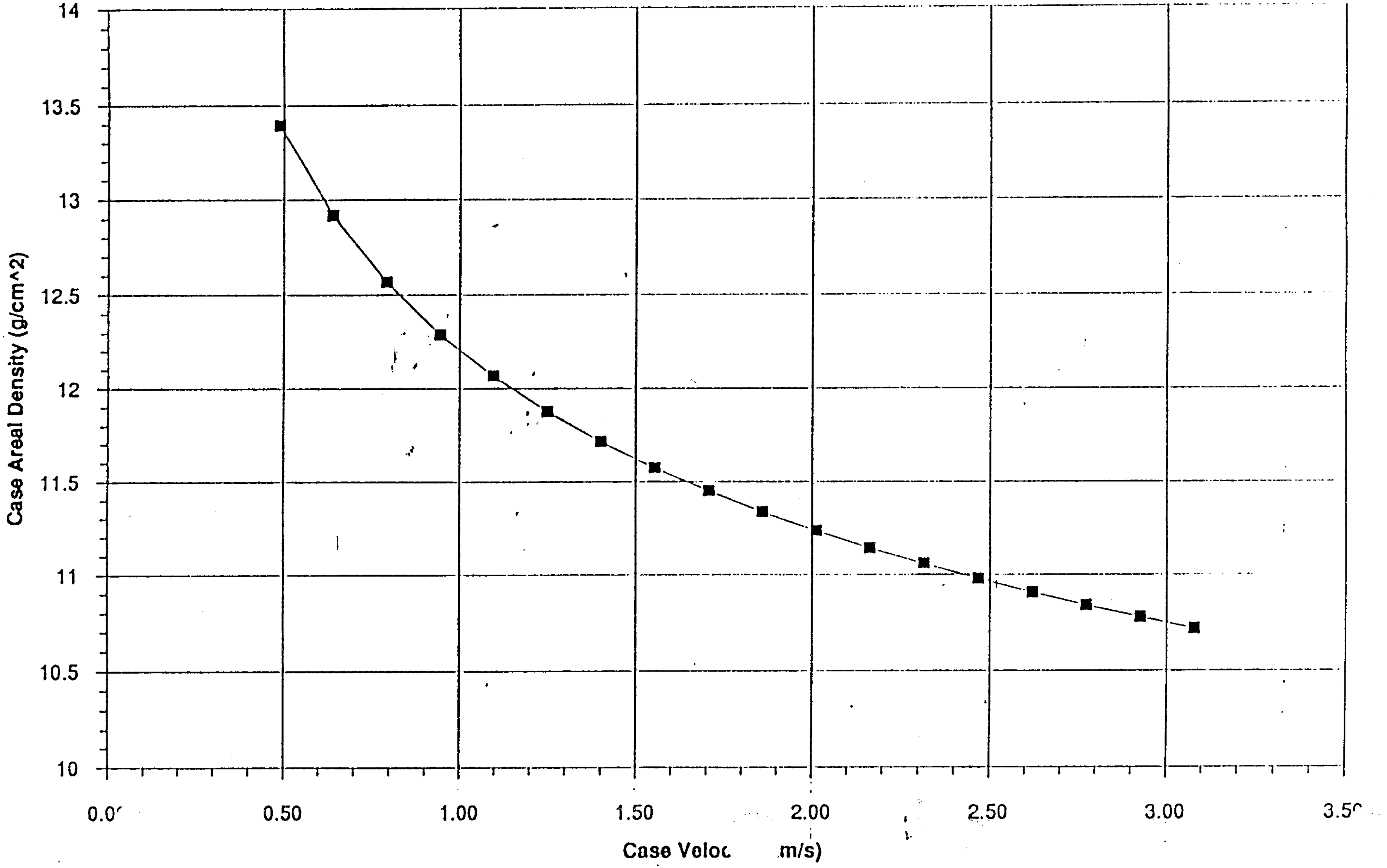
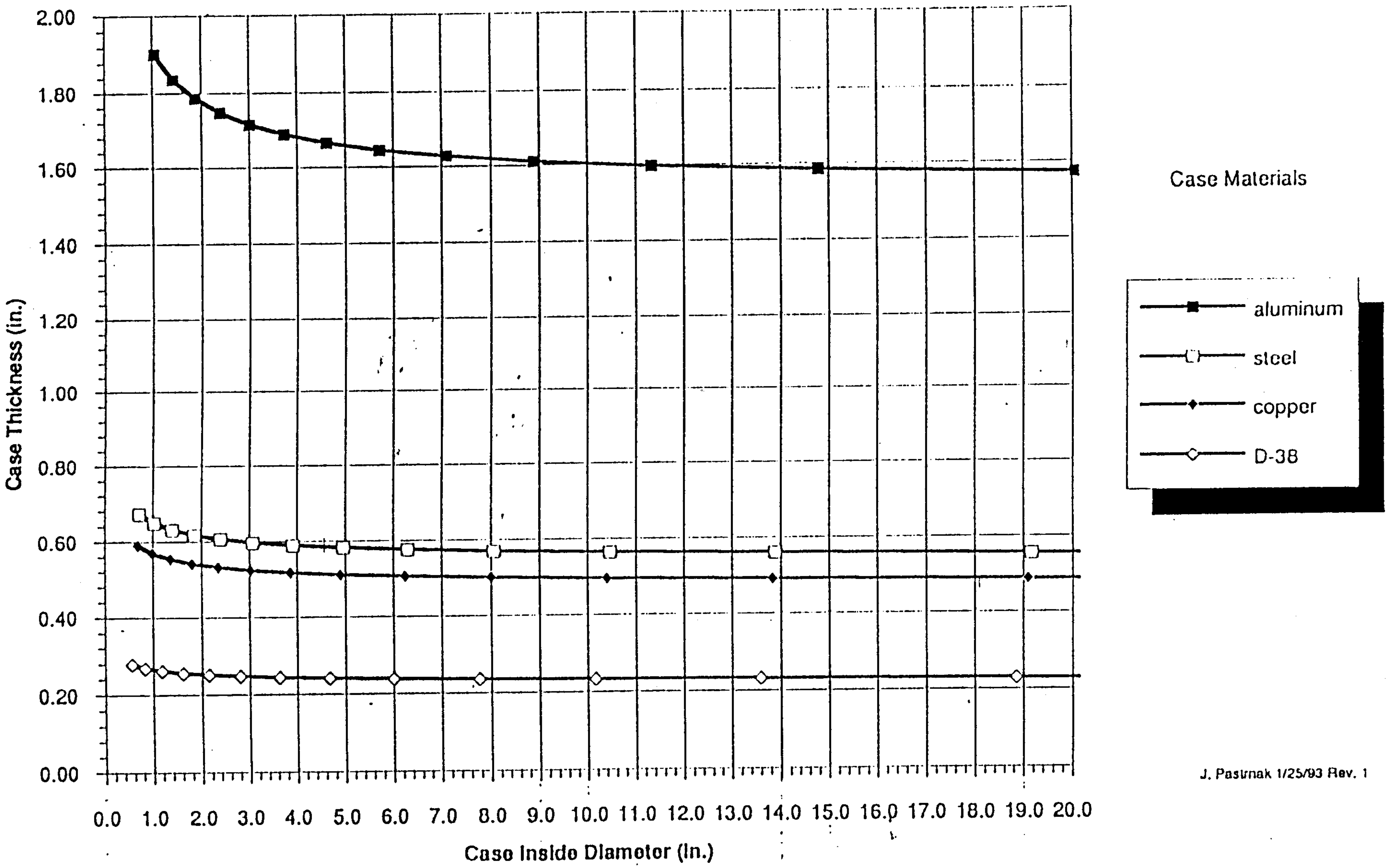


Figure 6

Case thickness vs. case inside diameter to keep primary fragments from un-shielded shots within a radius of 3000 feet

(combinations of case thickness and inside diameter above each material curve result in fragments that travel more than 3000 ft.)

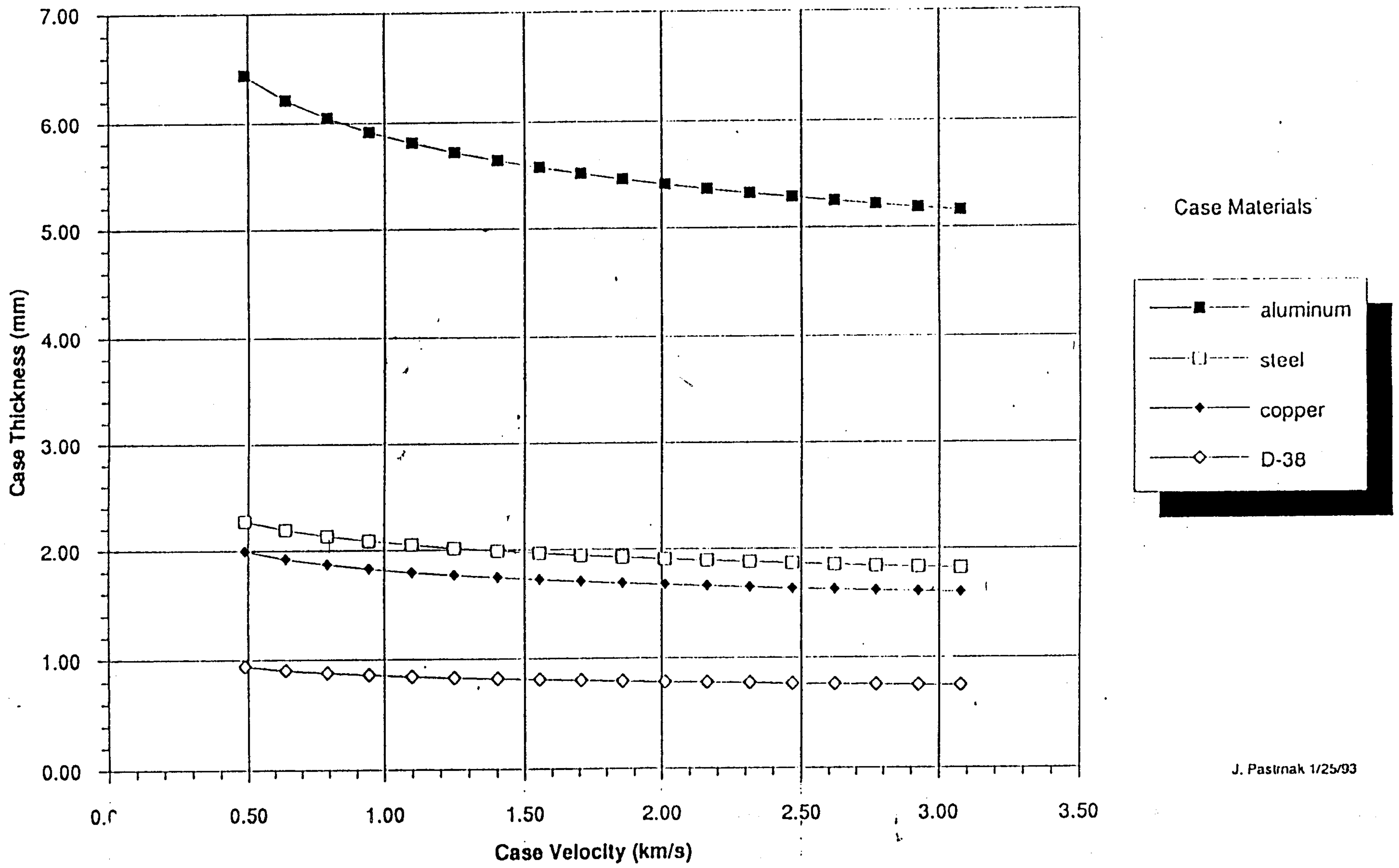


B801 Local Muster

Figure 7

Case thickness vs. case radial velocity to keep primary fragments from un-shielded shots within a radius of 400 feet

(combinations of case thickness and inside diameter above each material curve result in fragments that travel more than 400 ft.)



J. Pastrnak 1/25/93

Figure 8

Case areal density vs. case radial velocity to keep primary fragments from un-shielded shots within a radius of 400 feet

(combinations of areal density and velocity above the curve result in fragments that travel more than 400 ft.)

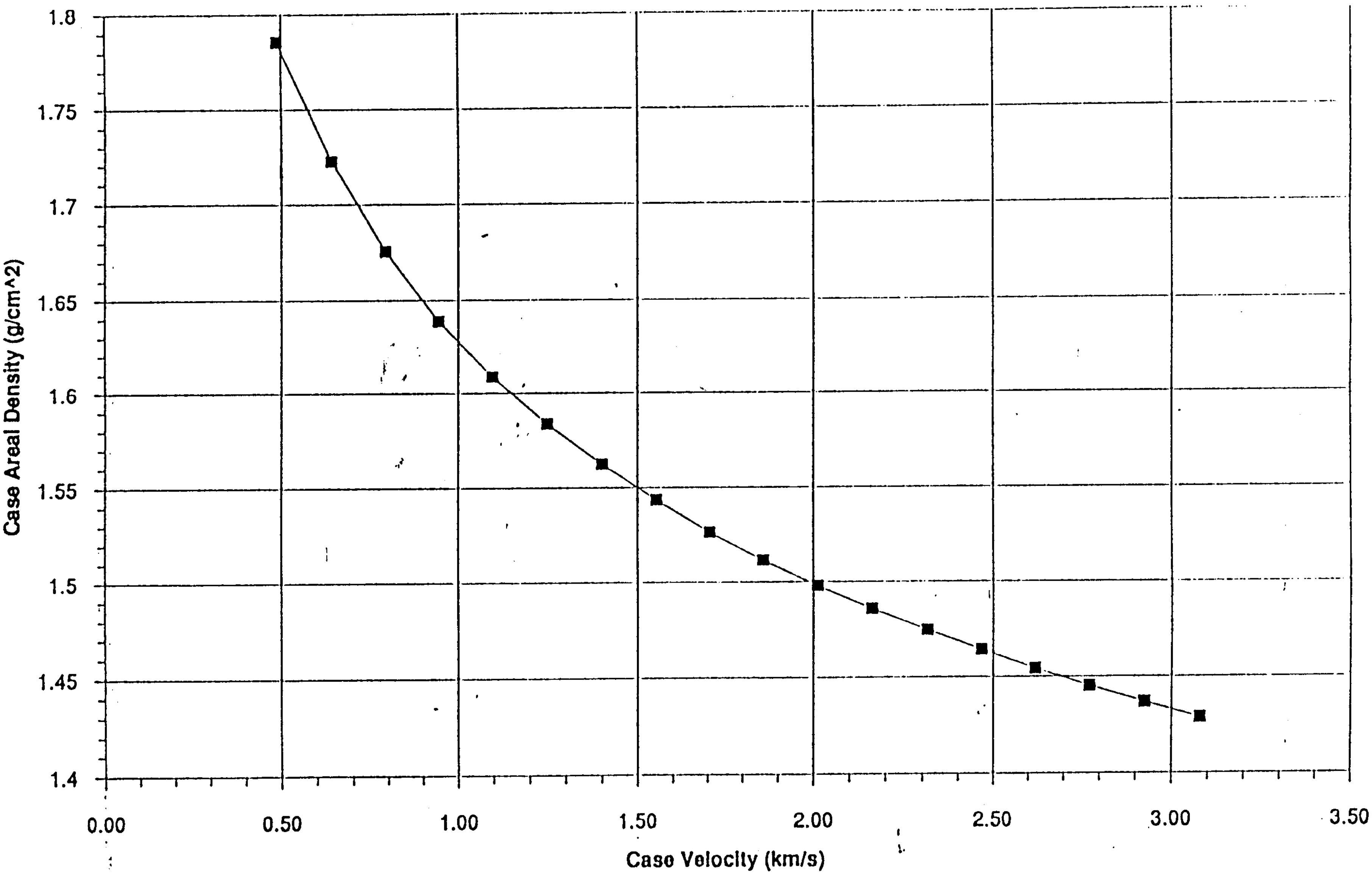
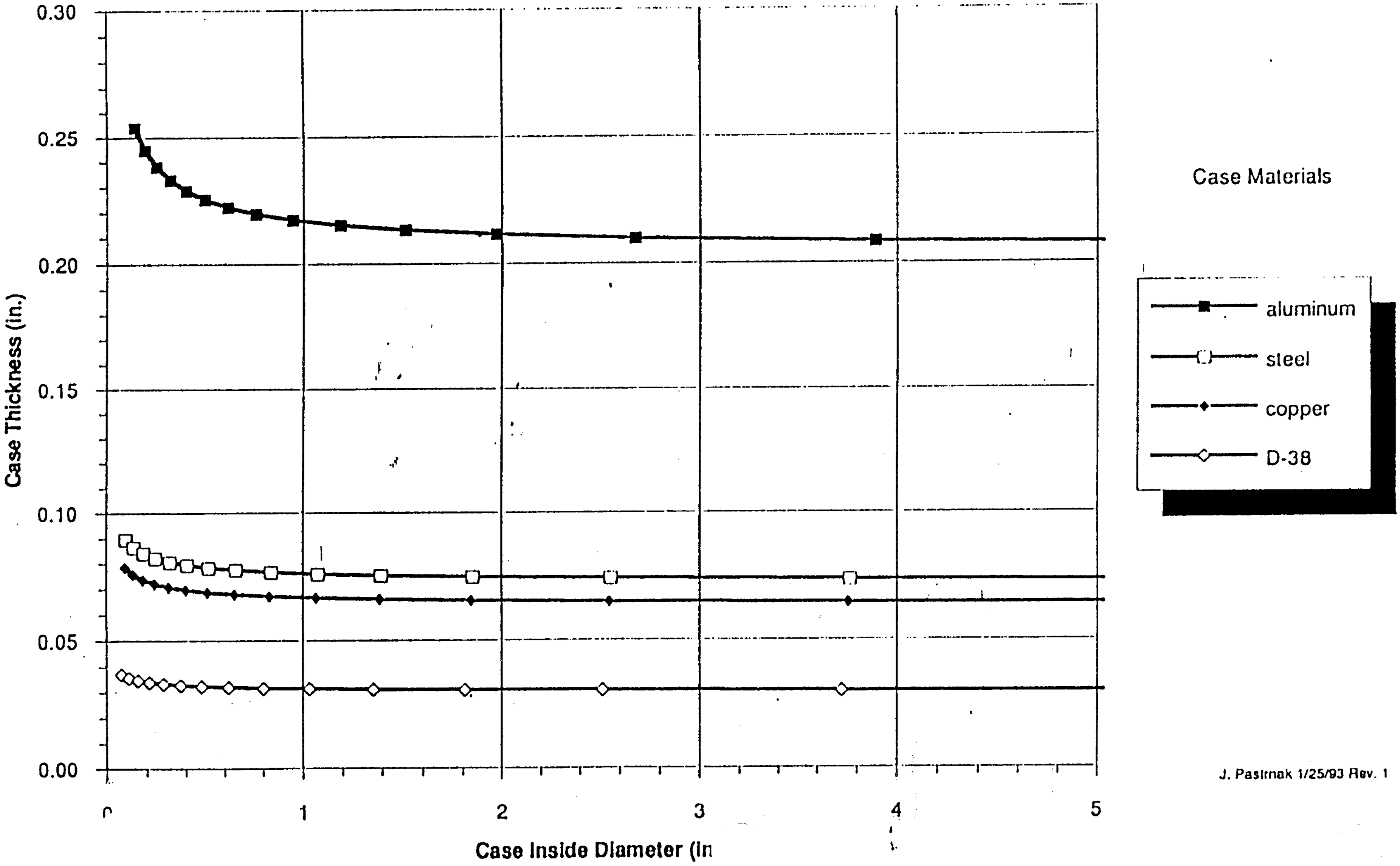


Figure 9

Case thickness vs. case inside diameter to keep primary fragments from un-shielded shots within a radius of 400 feet

(combinations of case thickness and inside diameter above each material curve result in fragments that travel more than 400 ft.)



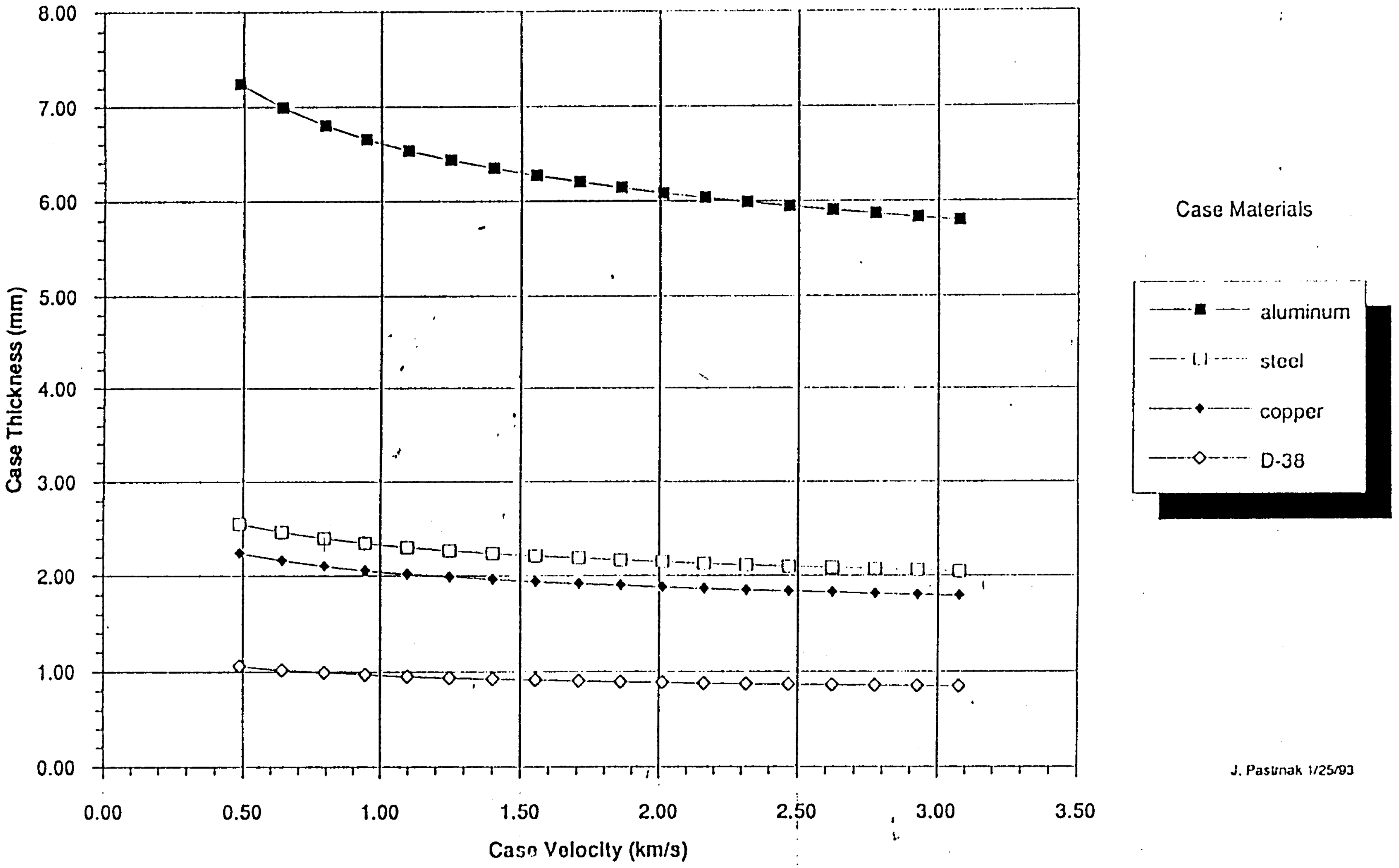
J. Pastrnak 1/25/93 Rev. 1

B851 Local Muster

Figure 10

Case thickness vs. case radial velocity to keep primary fragments from un-shielded shots within a radius of 450 feet

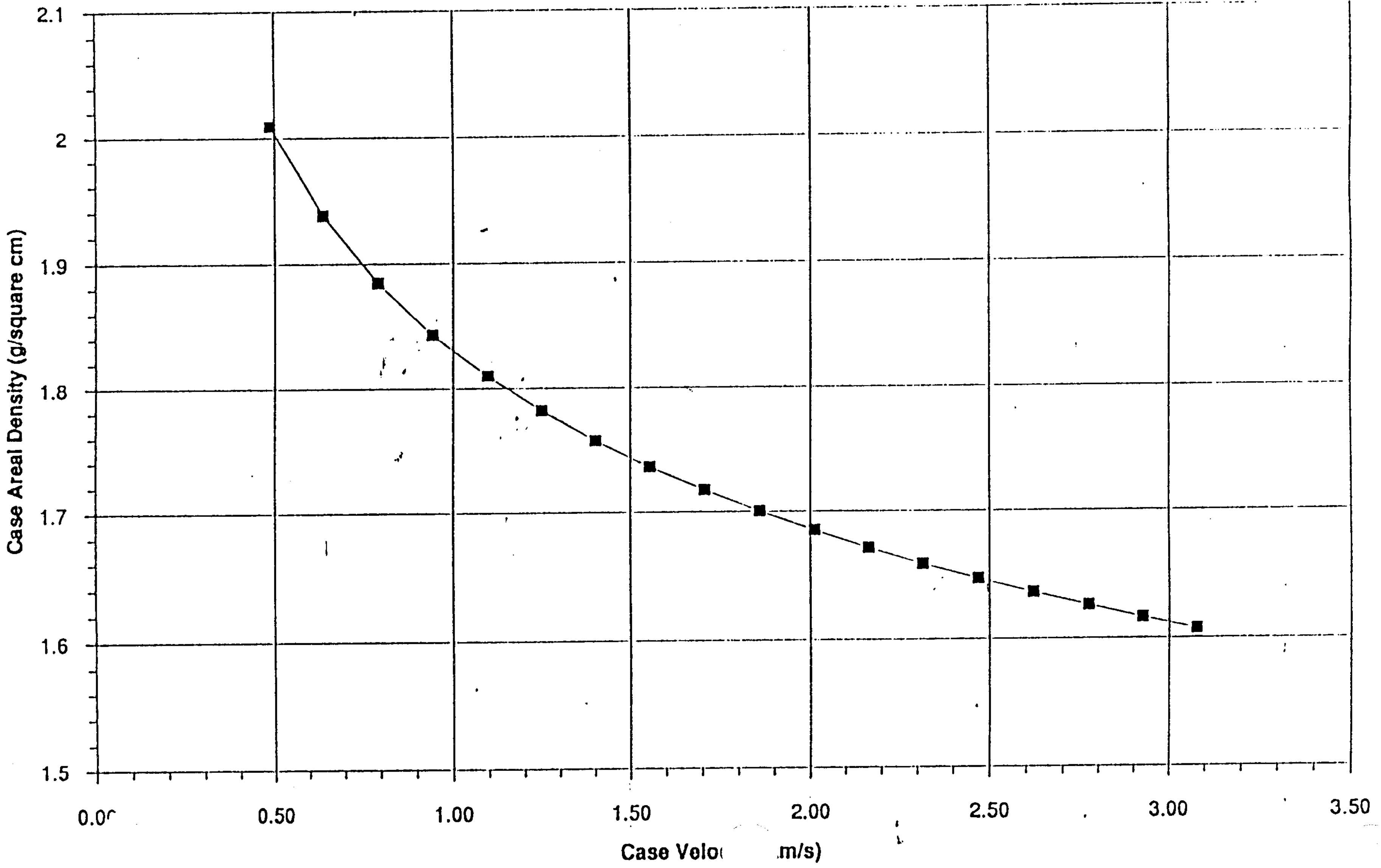
(combinations of case thickness and inside diameter above each material curve result in fragments that travel more than 450 ft.)



J. Pastrnak 1/25/93

Figure 11

Case areal density vs. case radial velocity to keep primary fragments from un-shielded shots within a radius of 450 feet



(combinations of areal density and velocity above the curve result in fragments that travel more than 450 ft.)

Figure 12

Case thickness vs. case inside diameter to keep primary fragments from un-shielded shots within a radius of 450 feet

(combinations of case thickness and inside diameter above each material curve result in fragments that travel more than 450 ft.)

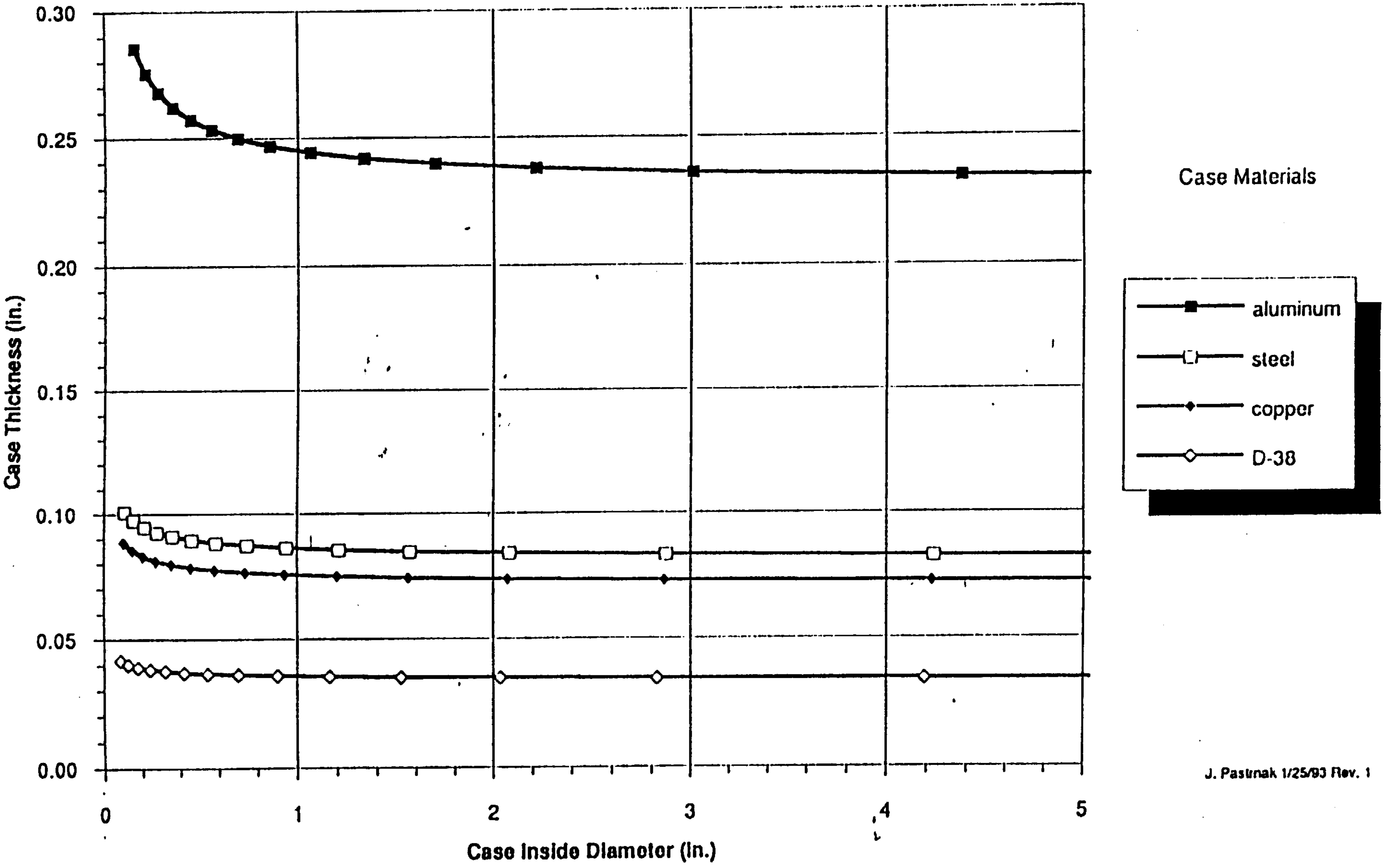


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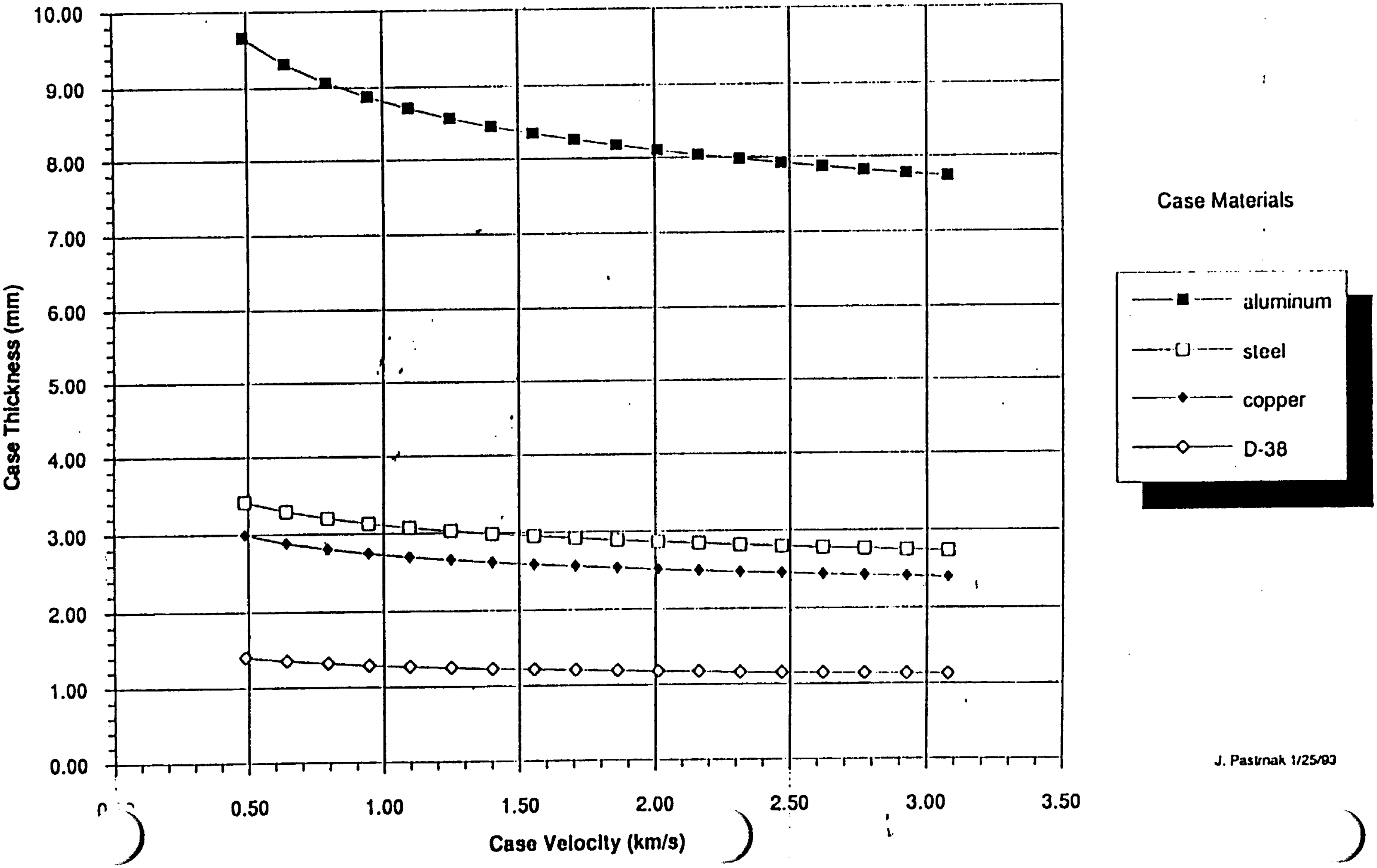
Figure 13

Case thickness vs. case radial velocity to keep primary fragments from un-shielded shots within a radius of 600 feet

(combinations of case thickness and inside diameter above each material curve result in fragments that travel more than 600 ft.)



J. Pastrnak 1/25/93

Figure 14

Case areal density vs. case radial velocity to keep primary fragments from un-shielded shots within a radius of 600 feet

(combinations of areal density and velocity above the curve result in fragments that travel more than 600 ft.)

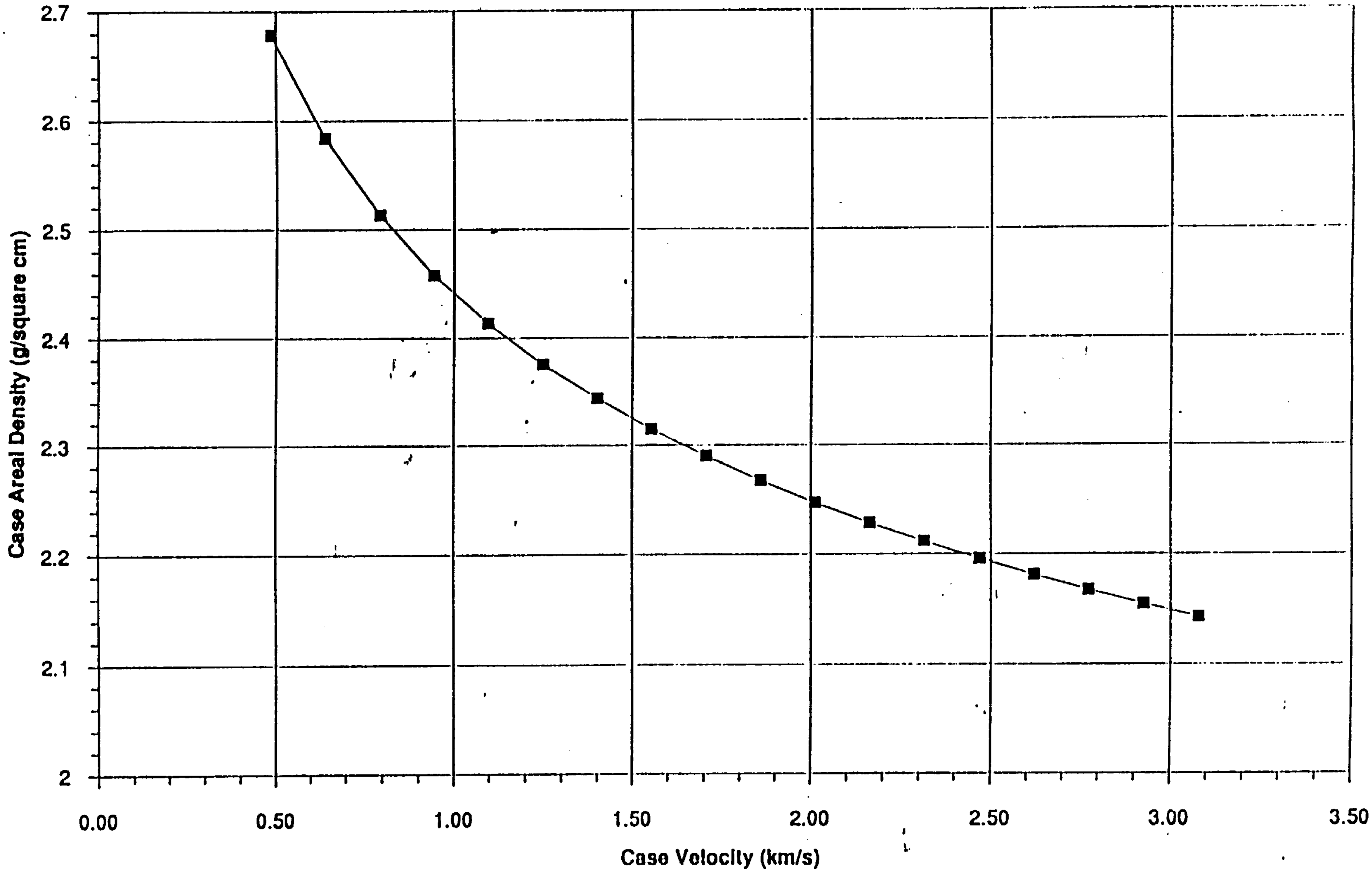
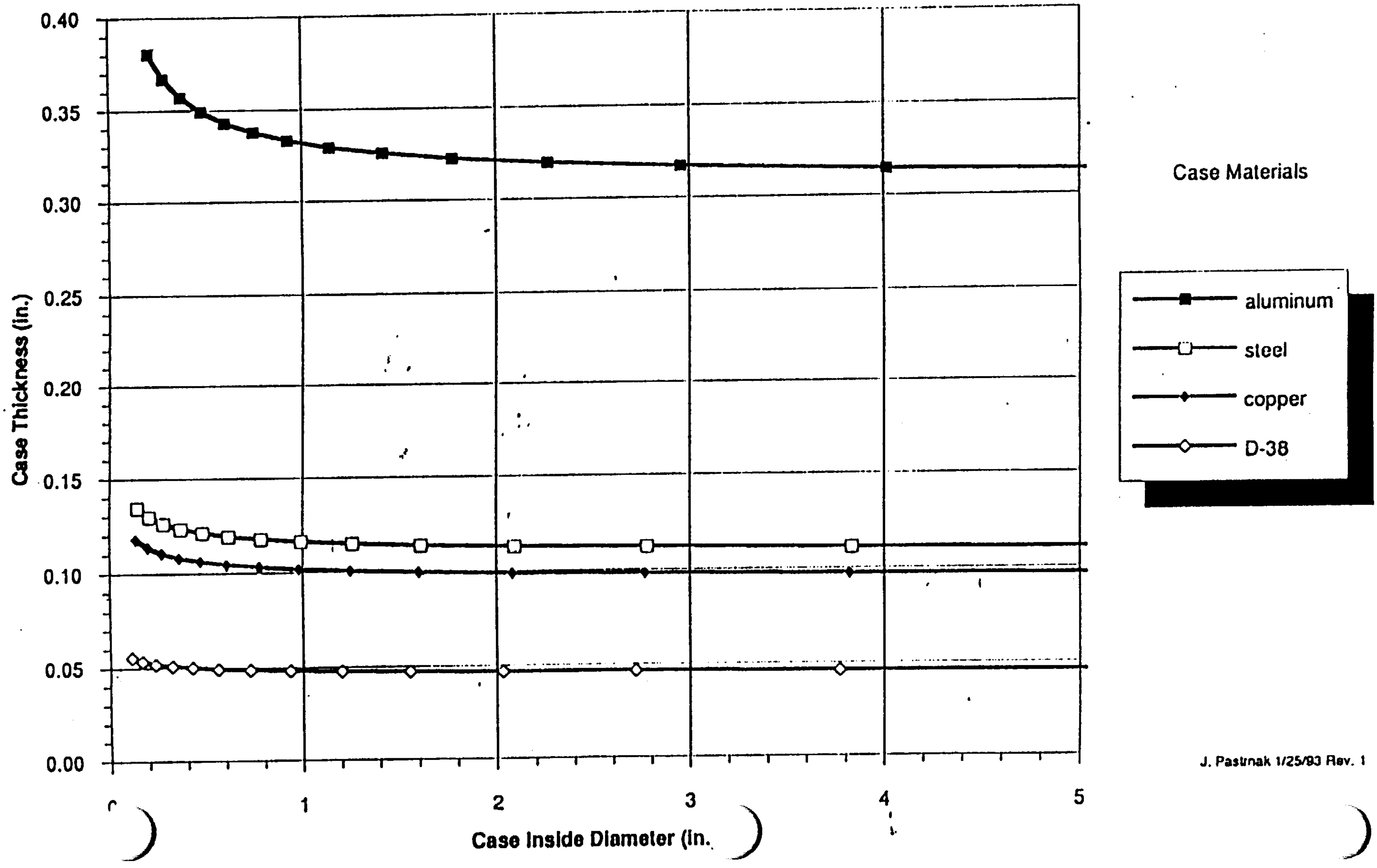


Figure 15

Case thickness vs. case inside diameter to keep primary fragments from un-shielded shots within a radius of 600 feet

(combinations of case thickness and inside diameter above each material curve result in fragments that travel more than 600 ft.)



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LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 300 4/20/93

B-DIVISION FIRING AREA ACCESS AND MUSTER CONTROL SYSTEM

APPENDIX B

HE WEIGHT LIMITATIONS AS A FUNCTION OF DISTANCE FOR 140 dB IMPULSIVE NOISE

Interdepartmental letterhead

Mail Station L-281

Ext: 28403

COMDU-93-0012
March 8, 1993

To: Kent Haslam

From: John Pastrnak

Subject: Site 300 High Explosive Weight Limitations based on Impulsive Noise (END93-015)

As requested, a plot of distance (R) versus high explosive weight (W) has been produced to provide guidance for limiting the impulsive noise resulting from open air detonations. The reason for this restriction is the 140 dB limit imposed by OSHA[1] for impulsive noise exposures. The HE weight limits published[2,3] previously for Local and Area Musters to comply with the 140 dB restriction agree with and are consistent with the values presented in Figure 1. Figure 1 was constructed from BRL data[4] of distance versus sound pressure for 1 to 10,000 lbs TNT. The BRL data is based on a zero vertical wind velocity gradient using TNT explosive charges. A TNT Blast equivalency factor of 1.3 is assumed as an upper bound for all high explosives used at Site 300 and is factored into the data plotted in Figure 1. The following constant *scaled distance* cube root relation appears to fit the BRL data quite well:

$$R = 585\left(\sqrt[3]{1.3W}\right)$$

where:

R = Required distance *(feet)* from detonation site where the impulsive noise equals 140 dB over pressure.
W = Weight *(lbs.)* of high explosive.

Actual 140 dB limit distances "R" may vary from Figure 1 due to wind speed, direction, temperature, non-zero vertical velocity gradients, and terrain effects which are not accounted for in this guideline.

John Pastrnak
Nuclear Explosives Engineering Division
Site 300 Lead Engineer

University of California
Lawrence Livermore
National Laboratory

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[1] Code of Federal Regulations, U.S. Department of Labor Occupational Safety and Health Administration, §1926.52, item (e), July 1, 1990.

[2] Baker, C.F. & Pastrnak, J. W., Revised Site 300 local muster area blast and fragment hazard calculations for buildin 850, and 851, LLNL internal memo to K. Haslam, April 6, 1992.

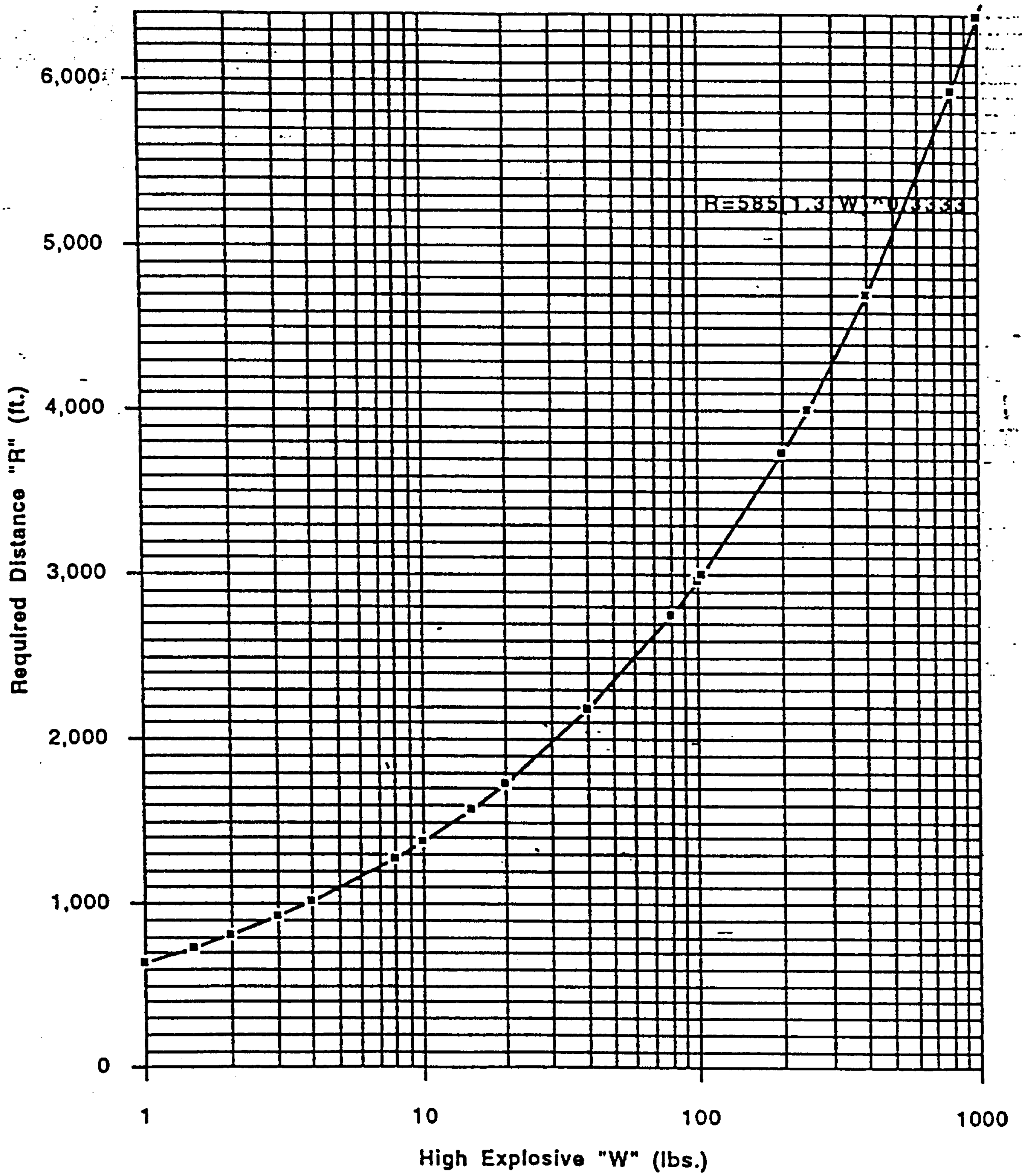
[3] Baker, C.F. & Pastrnak, J. W., Blast Hazard Calculations for the Site 300 Firing Areas, LLNL internal memo to K. Haslam, November 2, 1992.

[4] Perkins, B. & Jackson, W.F., Handbook For Prediction of Air Blast Focussing, Ballistic Research Laboratories, Rerport No. 1240, February, 1964, Figure 8, page 27.

Figure 1

Distance vs. High Explosive Weight for Detonations that produce 140 dB Impulsive Noise.

(Ref. Handbook For Prediction Of Air Blast Focussing, BRL Report 1240, Feb 1964).



LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 406 10/1/90

ENVIRONMENTAL PROCEDURE FOR CHARACTERIZATION, ACCUMULATION, AND TEMPORARY STORAGE OF HAZARDOUS WASTES IN CONTAINERS

I. INTRODUCTION

A. General

This procedure covers the handling (characterization, accumulation, and temporary storage in containers) of hazardous wastes generated at Site 300 by operations of the East and West Firing Areas; the Physical, Environmental, and Dynamic Test Areas; the Chemistry Area; the Process Area; and the General Service Area.

Hazardous wastes are defined in this procedure to include containerable wastes listed as hazardous by the Environmental Protection Agency (EPA) or California Department of Health Services (DHS) or any waste material that is ignitable, toxic, reactive, or corrosive (see 40 CFR 261.20). Radioactive wastes and mixed (hazardous and radioactive) wastes are described in more detail in Procedure No. 404. Also, wastes that are stored in hazardous waste tanks or non-hazardous or "sewerable" wastes in retention tanks are excluded from discussion herein but are covered in companion procedures.

The specific Waste Accumulation Areas (WAAs) and facilities affected by this procedure are listed below by general areas, as are the hazardous wastes of concern to each area.

East and West Firing Areas

- WAAs: 801, 851, 865
- Wastes Generated: solvents, lubricating fluids, dielectric fluids, bright dip tank wastes, photographic wastes, rags

Physical, Environmental, and Dynamic Test Area

- WAAs: 834, 836
- Wastes Generated: solvents, lubricating fluids, rags

Chemistry Area

- WAAs: 827-D, 827-E
- Wastes Generated: miscellaneous laboratory waste, solvent-contaminated rags, HE waste

Process Area

- WAAs: 829, 805, 823
- Wastes Generated: mock HE, solvents, lubricating fluids, photographic wastes, HE waste

General Service Area

- WAAs: 843, 875, 879, 819
- Wastes Generated: solvents, lubricating fluids, paints, rags, asbestos, contaminated soil boring cuttings, contaminated wastewater

B. Purpose of this Procedure

How the wastes generated at these facilities are labeled, accumulated, characterized, and temporarily stored in containers at Site 300 workplace accumulation areas and WAAs is the focus of this procedure. Where appropriate, reference is made to other procedures that define specific operations in greater detail.

The purpose of this procedure is to ensure proper waste management practices at Site 300 by defining waste handling specifications (e.g., for use of containers or characterization practices); documenting procedures for sampling, analyzing, staging, and certifying hazardous waste materials; identifying environmental safety issues related to hazardous waste management operations; and setting forth training and record keeping requirements.

C. Changes to this Procedure

Any change in operations that alters the scope or significantly decreases safety or environmental control will not be made until a revision or supplement to this procedure has been signed by those reviewing and approving this procedure. Any minor change that does not decrease the safety or environmental control may be made with the joint written concurrence of the Site 300 Hazards Control Safety Team Leader and the Nuclear Design Environmental Assurance Manager.

D. Review

Although Facility Safety Procedures (FSPs) are normally reviewed triennially, this procedure shall be reviewed annually by those reviewing and approving this procedure. This deviation from the normal FSP review process is being established to ensure that the contents of this procedure are current and appropriate for operations and in compliance with EPA, State of California, DOE, and San Joaquin Country requirements.

II. RESPONSIBILITIES

The responsibilities of the **Hazardous Waste Generator** include:

- Identify waste as potentially hazardous
- Properly segregate, label, and store waste
- Select proper waste container after consulting with HWM Technician
- Fill out HW label and affix to the waste container
- Package hazardous waste
- Fill out Disposal Requisition Form
- Move waste from the area of generation to the WAA

The **Program WAA Coordinator's** responsibilities include:

- Operating and maintaining the WAA
- Inspecting the WAA hazardous waste portable tanks and containers using the attached inspection form once a week
- Maintaining current contingency plans at the WAA
- Inspecting non-portable hazardous waste retention tanks daily using the attached inspection form
- Responding to spills according to the contingency plan located at the WAA
- Maintaining records of inspections, contents, and analyses

Waste handling responsibilities of the **Health and Safety (H&S) Technicians** include:

- Verifying packaging and labeling
- Signing off on the Disposal Requisition Form
- Responding to spills according to contingency plan located at WAA

Waste handling responsibilities of the **Environmental Analyst** are to guide, train, and assist generators, H&S Techs, and HWM Techs on LLNL practices and regulatory concerns in the following:

- Proper identification, labeling, packaging, and transportation of hazardous wastes
- WAA maintenance
- Sampling requirements and protocol
- Wastewater management and retention systems
- Air quality management and permitting
- Other environmental/hazardous waste concerns (PCBs, asbestos, etc.)
- Spill response
- Review WAA Contingency Plans and updates
- Coordinate inspections by regulatory agencies
- Make recommendations to programs on items requiring corrective measures

The **Hazardous Waste Management (HWM) Field Technician** works with Program WAA coordinators to manage waste properly:

- Inspects all WAAs for proper packaging, labeling, and paperwork
- Samples waste containers
- Expedites samples and requisition forms
- Coordinates transportation of waste from WAAs to Building 883
- Prepares waste for off-site shipment

III. HAZARDS ANALYSIS

Solid and liquid hazardous waste materials are generated by Site 300 program operations (see Section I.A.). HWM requires all wastes to be identified prior to pick-up from the WAAs. Guidelines for waste management are set forth in "Guidelines for Waste Accumulation Areas" (UCAR 10192, Rev. 1) and "Preparation Guide for Generators of Hazardous Chemicals and Radioactive Waste at LLNL" (Appendix B, UCAR 10192). For proper identification of hazardous wastes, the generator must complete the Hazardous Waste Disposal Requisition Form and provide analytical data (see Section IV.A.) as appropriate. "Wastes" also consist of outdated chemicals and unlabeled material left behind when programs or personnel terminate. LLNL generators are advised to leave unknown chemicals in place until they are properly identified and labeled. Trained hazardous waste management specialists are available to assist in identifying the unknown chemicals and disposing of them appropriately.

IV. OPERATIONAL CONTROLS

Site 300 has four types of HWM Units: workplace accumulation areas, WAAs, a RCRA-permitted storage facility (Bldg. 883), and an interim status Open Burn Area (Bldg. 829). This procedure limits discussion to the first two HWM units.

A. Characterization of Hazardous Wastes

The HWM requisition system requires that an analysis sample number or profile number be entered on the Disposal Requisition Form to ensure the waste is properly characterized. The standard procedures for obtaining these numbers are as follows:

1. Chemical Analysis. For infrequent, changing, or certain repetitive waste streams, an analysis must be made of the waste composition before the waste is accepted by the WAA (from a workplace accumulation area) or by HWM (from the WAA). The HWM Field Technician collects a sample and sends it to the LLNL hazardous waste control lab for analysis. The HWM Field Technician receives results back in 2 to 3 weeks, enters the sample number for the completed analysis on the form, and provides a copy of the completed form to the generator.

2. Profiling. For certain repetitive waste streams of unchanging composition, a generator can "profile" the waste to save time and money. The generator, with the help of the Environmental Analyst, identifies the profiled waste and completes a Profile Form. The analysis number for the profile is then entered on the Disposal Requisition Form in the Analysis Sample No. space, and the waste description, as written on the profile sheet, is entered. Profiled wastes are reanalyzed either quarterly or semi-annually, depending on regulatory requirements.

"Knowledge of process" wastes are an exception to the above. A waste whose composition can be determined based on knowledge of the process may not need to be analyzed prior to HWM handling. This method of characterization must be coordinated with the Site 300 Environmental Analyst.

Unknown wastes present special problems because it is often impossible to determine the program or process that generated the waste material, its age or stability, etc. Because analyses can be costly and time consuming, all attempts are made to determine the probable contents based on any known details (room number where found, name of user, etc.). If possible, unknown wastes are left in place until properly identified and labeled.

B. Packaging and Labeling of Hazardous Wastes for Temporary Storage

Containers shall meet specifications of 49 CFR 173.425(B)(1) to ensure integrity during normal handling and transport conditions. Containers must be of a material compatible with the wastes to be contained, or must be lined with a compatible material (e.g., poly-lined containers are used for acid wastes). The generator is responsible for using the proper waste container after consulting with HWM. HWM will furnish all 55-gallon drums and wooden boxes. Five-gallon containers shall be obtained through the Site 300 Supply Storeroom (Bldg. 875). Other DOT containers, such as DOT metal containers, shall be ordered through the LLNL Procurement Department. Each generator should keep a small supply of containers applicable to program needs at their facility to allow timely removal of wastes from the point of generation.

The following containers are approved for use in storage of hazardous liquid wastes at Site 300:

- 6D-2S (white) poly-lined 55-gallon drum
  -corrosives only
  -no chlorinated solvents
- 17E (white) unlined 55-gallon drum
  -no corrosives
- 17E (grey) 5-gallon metal can
  -no corrosives
- DOT-34 5-gallon carboy
  -no chlorinated solvents.

Solid hazardous wastes can be contained in any of the following:

- 7A4' x 4' x 7' wood box
- 7A2' x 4' x 7' wood box
- 17C (grey) open head 55-gallon drum
- DOT-approved metal containers

A red and white hazardous waste label (HWL) (Stores Stock #4280-71110) must be affixed to a container when waste is first placed into the container. This means the generator is responsible for affixing this label and identifying the waste and the "Fill Start" date. Note: Labels should be checked to make sure that the correct label is being used. The correct Site 300 label has the Site 300 address printed on it.

C. Management of Hazardous Wastes Accumulated at the Workplace Accumulation Areas

1. Wastes may be "accumulated" in the workplace. Accumulation is defined as the continual addition of waste to a container; it is not storage of a full container. The generator may accumulate up to 55 gallons of hazardous waste (or one quart of acutely or extremely hazardous waste) at or near the point of generation for a period of 9 months. When either the time or quantity limitation is reached, the container must be moved to a WAA within 3 days.

2. Incompatible wastes must be physically separated (e.g., flammables must be separated from oxidizers, and bases from acids, but flammables and bases may be sited together). Appendix B-3 of the EPD guidance document "Preparation Guide for Generators of Hazardous Chemicals and Radioactive Waste at LLNL" should be used to check the compatibility of chemicals. This appendix is included as Attachment 1 of this procedure.

3. The generator is responsible for filling in the "Fill End" date on the HWL and for filling out the Disposal Requisition Form. Packaging and labeling is verified by the H&S Tech, who then signs off on the Disposal Requisition Form.

4. The generator is responsible for moving the waste from the point of generation (or the workplace accumulation area) to the WAA.

D. Management of Wastes Stored at Waste Accumulation Areas

The individual WAAs are maintained by waste generating programs and each has a Program WAA Coordinator (see Section II for description of responsibilities). WAAs are designed for the temporary storage of waste (less than 90 days) and must meet minimum safety and environmental protection standards (see UCAR 10192: "Guidelines for Waste Accumulation Areas").

1. Wastes received from workplace accumulation areas should arrive completely labeled. Wastes being accumulated at the WAA are labeled there and must list the Accumulation Start Date as the date when waste is first added to the container. Waste accumulation at the WAA follows the same

procedures as outlined for the workplace accumulation areas for segregation and verification of contents. Containers are kept closed at all times, except when adding waste.

2. WAAs are inspected weekly using the form included as Attachment 2 to ensure that area is adequately posted (hazard/cautionary signs and the current Contingency Plan) and free of spills. As agreed upon by the Site 300 Management Staff, each Facility Supervisor verifies that the Program WAA Coordinator has performed the required weekly inspection by placing his/her initials in the top right corner of the completed inspection form. The secondary containment basins must be free of liquid and debris and emergency equipment must be present and in operating condition. The Program WAA Coordinator also checks to ensure the HWM requisition forms are properly filled out.

3. Containers are inspected weekly to ensure that they are all labelled completely, that none has exceeded the 90-day storage limit, that all are adequately separated (incompatibles from each other) or isolated (ignitables from sources of ignition and at least 50' from the Site perimeter fence). Containers are also checked to ensure they are in good condition, are compatible with the wastes stored inside, and are closed (except when wastes are being added).

4. Wastes stored at the WAA are inspected by the HWM Field Tech, who signs the Disposal Requisition Form for verifying the waste is safe for transport. HWM (LLNL Livermore Site) reviews the form and returns the bottom two copies. The green copy is attached to the container (the blue copy is filed), and the approved waste container is picked up by HWM for transport to the LLNL HWM facilities at the Livermore Site.

E. Personnel Control

To limit hazards to personnel or to the environment, all personnel working in waste handling must receive specialized training and all WAAs are set away from vehicular traffic by some sort of barricade and posted with cautionary signs.

1. All WAAs have emergency/safety equipment in place. The equipment consists of such items as spill kits, fire extinguishers, eye washes, first aid kits, and a phone in close proximity. The equipment specific to each WAA is listed in its Spill Response Plan and in the individual WAA Contingency Plans.

2. The Contingency Plans also contain response procedures for applicable waste types and these procedures include steps to take to protect personnel in the area or those who come in contact with the waste.

3. Technical training is required for all personnel who handle hazardous wastes. All generators and Program WAA Coordinators shall complete the EP-006 Hazardous Waste Generator training and shall have an annual EP-006 refresher course.

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Appendix B-3. Guide to Chemical Compatibility

Provided in this appendix is a chemical compatibility guide adapted from that developed by the U.S. Coast Guard.[1] The guide is based in part upon information provided to the Coast Guard by the National Academy of Sciences, U.S. Coast Guard Advisory Committee on Hazardous Materials. It serves as an excellent "rule of thumb" guide for relatively common materials. Another useful guide is *A Method of Determining the Compatibility of Hazardous Wastes.*[2]

Chemical Compatibility Guide

Accidently mixing one chemical compound with another may in some cases result in a hazardous chemical reaction. The consequences of such a reaction include the generation of toxic gases; the heating, overflowing, and rupturing of containers; and fire and explosion. The chemical compatibility chart in Table B3-1 shows combinations of chemicals that are dangerously reactive when mixed. Note, however, that the table provides a broad grouping of chemicals with an extensive variety of possible binary combinations. Although one group can be considered dangerously reactive with another group where an "X" appears in the table, there may exist between the groups some combinations that would not dangerously react. This chart is offered to aid you in the safe handling of chemicals. It should not be used as an infallible guide. Take the proper safeguards to prevent accidental mixing of the two chemicals for which an "X" appears in the table.

Follow these procedures when determining the compatibility of chemicals:

1. Determine the reactivity group of a particular product by referring to the alphabetical list in Table B3-2.
2. Once you have determined the number of the reactivity group, return to Table B3-1. Find that number and its associated reactivity group in the column at the left of the table. Proceed across the page. An "X" indicates a reactivity group that forms an unsafe combination with the chemical compound in question. For example, according to Table B3-2, crotonaldehyde belongs to group 19 (Aldehydes). Table B3-1 shows that chemicals in this group should be separated from sulfuric and nitric acids, caustics, ammonia, and all types of amines (aliphatic, alkanol, and aromatic). The notes at the bottom of the table refer to specific reactivity hazards within a group. An "X" is not used because all members of the group do not share this reactivity hazard. According to note A at the bottom of Table B3-1, crotonaldehyde is also incompatible with non-oxidizing mineral acids.

There are wide variations in the reaction rates of individual chemicals within those groups shown to be reactive in Table B3-1. Table B3-3 lists examples of chemical compounds in the various reactivity groups.

References

B3-1. "Guide to Chemical Compatibility," *Hazardous Chemicals Data Book*, G. Weiss, Ed. (Noyes Data Corporation, 1980), pp. 19-32.
B3-2. H. K. Hatayama et al., *A Method of Determining the Compatibility of Hazardous Wastes*, National Technical Information Service, PD80-211005 (1980).

Table B3-1. Chemical compatibility chart. An "X" indicates a reactivity group that forms an unsafe combination with the chemical compound in question.

REACTIVITY GROUPS / REACTIVITY GROUPS	1. NONOXIDIZING MINERAL ACIDS	2. SULFURIC ACID	3. NITRIC ACID	4. ORGANIC ACIDS	5. CAUSTICS	6. AMMONIA	7. ALIPHATIC AMINES	8. ALKANOLAMINES	9. AROMATIC AMINES	10. AMIDES	11. ORGANIC ANHYDRIDES	12. ISOCYANATES	13. VINYL ACETATE	14. ACRYLATES	15. SUBSTITUTED ALLYLS	16. ALKYLENE OXIDES	17. EPICHLOROHYDRIN	18. KETONES	19. ALDEHYDES	20. ALCOHOLS, GLYCOLS	21. PHENOLS, CRESOLS	22. CAPROLACTAM SOLUTION			
1 NONOXIDIZING MINERAL ACIDS		X			X	X	X	X	X	X	X	X	X			X	X		A	E					1
2 SULFURIC ACID	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			2
3 NITRIC ACID		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				3
4 ORGANIC ACIDS		X			X	X	X	X	C			X				X	X			F					4
5 CAUSTICS	X	X	X	X							X	X				X	X		X	X	X	X			5
6 AMMONIA	X	X	X	X						X	X	X	X			X	X		X						6
7 ALIPHATIC AMINES	X	X	X	X							X	X	X	X	X	X	X	X	X	X	X	X			7
8 ALKANOLAMINES	X	X	X	X							X	X	X	X	X	X	X	B	X						8
9 AROMATIC AMINES	X	X	X	C							X	X							X						9
10 AMIDES	X	X	X			X						X									X				10
11 ORGANIC ANHYDRIDES	X	X	X		X	X	X	X	X																11
12 ISOCYANATES	X	X	X	X	X	X	X	X	X	X					D					X		X			12
13 VINYL ACETATE	X	X	X			X	X	X																	13
14 ACRYLATES		X	X				X	X																	14
15 SUBSTITUTED ALLYLS		X	X				X	X				D													15
16 ALKYLENE OXIDES	X	X	X	X	X	X	X	X																	16
17 EPICHLOROHYDRIN	X	X	X	X	X	X	X	X																	17
18 KETONES		X	X				X	B																	18
19 ALDEHYDES	A	X	X		X	X	X	X	X																19
20 ALCOHOLS, GLYCOLS	E	X	X	F	X		X					X													20
21 PHENOLS CRESOLS		X	X		X		X			X															21
22 CAPROLACTAM SOLUTION		X			X		X					X													22

Table B3-1. (Continued).

REACTIVITY GROUPS	1. NONOXIDIZING MINERAL ACIDS	2. SULFURIC ACID	3. NITRIC ACID	4. ORGANIC ACIDS	5. CAUSTICS	6. AMMONIA	7. ALIPHATIC AMINES	8. ALKANOLAMINES	9. AROMATIC AMINES	10. AMIDES	11. ORGANIC ANHYDRIDES	12. ISOCYANATES	13. VINYL ACETATE	14. ACRYLATES	15. SUBSTITUTED ALLYLS	16. ALKYLENE OXIDES	17. EPICHLOROHYDRIN	18. KETONES	19. ALDEHYDES	20. ALCOHOLS, GLYCOLS	21. PHENOLS, CRESOLS	22. CAPROLACTAM SOLUTION			
30 OLEFINS		X	X																						30
31 PARAFFINS																									31
32 AROMATIC HYDROCARBONS			X																						32
33 MISCELLANEOUS HYDROCARBON MIXTURES			X																						33
34 ESTERS		X	X																						34
35 VINYL HALIDES			X																			X			35
36 HALOGENATED HYDROCARBONS		G			H		I																		36
37 NITRILES		X																							37
38 CARBON DISULFIDE							X	X																	38
39 SULFOLANE																									39
40 GLYCOL ETHERS		X										X													40
41 ETHERS		X	X																						41
42 NITROCOMPOUNDS					X	X	X	X	X																42
43 MISCELLANEOUS WATER SOLUTIONS		X										X													43

Notes to compatibility chart: Letters A-I indicate additional reactivity hazards within a group. An "X" is not used because all members of the group do not share this reactivity hazard

A. Acrolein (19), Crotonaldehyde (19), and 2-Ethyl-3-Propyl Acrolein (19) are not compatible with group 1, Non-Oxidizing Mineral Acids.
B. Isophorone (18) and Mesityl Oxide (18) are not compatible with group 8, Alkanolamines.
C. Acrylic Acid (4) is not compatible with group 9, Aromatic Amines.
D. Allyl Alcohol (15) is not compatible with group 12, Isocyanates.
E. Furfuryl Alcohol (20) is not compatible with group 1, Non-Oxidizing Mineral Acids.
F. Furfuryl Alcohol (20) is not compatible with group 4, Organic Acids.
G. Dichloroethyl Ether (36) is not compatible with group 2, Sulfuric Acid.
H. Trichloroethylene (36) is not compatible with group 5, Caustics.
I. Ethylenediamine (7) is not compatible with Ethylene Dichloride (36).

Table B3-2. **Alphabetical listing of chemical compounds and their reactivity groups (whose numbers correspond to those in Table B3-1).**

Name	Reactivity group No.
Acetaldehyde	19
Acetic acid	4
Acetic anhydride	11
Acetone	18
Acetonitrile	37
Acrolein (inhibited)	19
Acrylic acid (inhibited)	4
Acrylonitrile (inhibited)	15
Adiponitrile	37
Allyl alcohol	15
Allyl chloride	15
Aminoethylethanolamine	8
Ammonia, anhydrous	6
Ammonium hydroxide (28% or less)	6
Ammonium nitrate, urea, water solutions (containing ammonia)	6
Ammonium nitrate, urea, water solutions (not containing ammonia)	6
Amyl acetate	34
Amyl alcohol	20
Amyl tallate	34
Aniline	9
Asphalt	33
Asphalt blending stocks	
Roofers flux	33
Straight run residue	33
Benzene	32
Benzene, toluene xylene (crude)	32
Butadiene (inhibited)	30
Butane	31
Butyl acetate	34
Butyl acrylate (inhibited)	14
Butyl alcohol	20
Butylamine	7
Butyl benzyl phthalate	34
Butylene	30
1,3-Butylene glycol	20
Butylene oxide	16
Butyl ether	41
Butyl methacrylate (inhibited)	14
Butyraldehyde	19
Butyric acid	4
Camphor oil (light)	18
Caprolactam solution	22
Carbolic oil	21
Carbon disulfide	38
Carbon tetrachloride	36
Caustic potash solution	5
Caustic soda solution	5
Chlorine	•

Table B3-2. (Continued).

Name	Reactivity group No.
Chlorobenzene	36
Chloroform	36
Chlorosulfonic acid	•
Corn syrup	43
Creosote, coal tar	21
Cresols	21
Cresylate spent caustic solution	5
Crotonaldehyde	19
Cumene	32
Cycloaliphatic resins	31
Cyclohexane	31
Cyclohexanol	20
Cyclohexanone	18
Cyclohexylamine	7
Cymene	32
Decaldehyde	19
Decane	31
Decene	30
Decyl alcohol	20
Decyl acrylate (inhibited)	14
Decylbenzene	32
Dextrose solution	43
Diacetone alcohol	20
Dibutylamine	7
Dibutyl phthalate	34
Dichlorobenzene	36
Dichlorodifluoromethane	36
1,1-Dichloroethane	36
Dichloroethyl ether	41
Dichloromethane	36
1,1-Dichloropropane	36
1,2-Dichloropropane	36
1,3-Dichloropropene	15
Dicyclopentadiene	30
Diethanolamine	8
Diethylamine	7
Diethylbenzene	32
Diethylene glycol	40
Diethylene glycol monobutyl ether	40
Diethylene glycol monobutyl ether acetate	34
Diethylene glycol monoethyl ether	40
Diethylene glycol monomethyl ether	40
Diethylenetriamine	7
Diethylethanolamine	8
Diheptyl phthalate	34
Diisobutylene	30
Diisobutyl carbinol	20
Diisobutyl ketone	18
Diisodecyl phthalate	34
Diisopropanolamine	8

Table B3-2. (Continued).

Name	Reactivity group No.
Diisopropylamine	7
Dimethylamine	7
Dimethylethanolamine	8
Dimethylformamide	10
Dinonyl phthalate	34
Dioctyl phthalate	34
1,4-Dioxane	41
Diphenyl-diphenyl oxide	33
Diphenylmethane diisocyanate	12
Di-n-propylamine	7
Dipropylene glycol	40
Distillates	
Straight run	33
Flashed feed stocks	33
Diundecyl phthalate	34
Dodecane	31
Dodecanol	20
Dodecene	30
Dodecylbenzene	32
Epichlorohydrin	17
Ethane	31
Ethanolamine	8
Ether acetate	34
Ethoxylated alcohols C11—C5	40
Ethoxy triglycol	40
Ethyl acetate	34
Ethyl acrylate (inhibited)	14
Ethyl alcohol	20
Ethylamine	7
Ethyl benzene	32
Ethyl butanol	20
Ethyl chloride	36
Ethylene	30
Ethylene chlorohydrin	20
Ethylene cyanohydrin	20
Ethylenediamine	7
Ethylene dibromide	36
Ethylene dichloride	36
Ethylene glycol	20
Ethylene glycol monobutyl ether	40
Ethylene glycol monobutyl	
Ethylene glycol monoethyl ether	40
Ethylene glycol monoethyl	
Ethylene glycol monomethyl ether	40
Ethylene oxide	*
Ethyl ether	41
Ethylhexaldehyde	19
2-Ethyl hexanol	20
2-Ethylhexyl acrylate (inhibited)	14
Ethyl hexyl tallate	34

Table B3-2. (Continued).

Name	Reactivity group No.
Ethyl methacrylate (inhibited)	14
2-Ethyl-3-propyl acrolein	19
Formaldehyde solution (37–50%)	19
Formic acid	4
Furfural	19
Furfuryl alcohol	20
Gas oil	
cracked	33
Gasoline blending stocks	
Alkylates	33
Reformates	33
Gasolines	
Casinghead (natural)	33
Automotive (containing over 4.23 g lead per gal)	33
Aviation (containing not over 4.86 g lead per gal)	33
Polymer	33
Straight run	33
Glutaraldehyde solution	19
Glycerine	20
Glycol diacetate	34
Glyoxal solution	19
Heptane	31
Hexamethyleneimine	7
Hexane	31
Hexanol	20
Hexene	30
Hexylene glycol	20
Hydrochloric acid	1
Hydrofluoric acid	1
Isophorone	18
Isoprene (inhibited)	30
Jet fuels: JP-1 (kerosene), JP-3, JP-4, JP-5 (kerosene, heavy)	33
Kerosene	33
Latex, liquid synthetic	43
Mesityl oxide	18
Methane	31
Methyl acetate	34
Methyl acetylene, propadiene Mixture (stabilizied)	30
Methyl acrylate (inhibited)	14
Methyl alcohol	20
Methyl amyl acetate	34
Methyl amyl alcohol	20
Methyl bromide	36
3-Methyl butyraldehyde	19
Methyl chloride	36
Methyl ethyl ketone	18
2-Methyl-5-ethyl pyridine	9

Table B3-2. (Continued).

Name	Reactivity group No.
Methyl formal (dimethyl formal)	41
Methyl isobutyl ketone	18
Methyl isobutyl carbinol	20
Methyl methacrylate (inhibited)	14
(Alpha-)Methyl styrene (inhibited)	30
Mineral spirits	33
Monochlorodifluoromethane	36
Morpholine	7
Motor fuel antiknock compounds containing lead alkyls	•
Naphtha: Coal tar, solvent, Stoddard solvent, Varnish Markers', and Painters' (75%)	33
Naphthalene (molten)	32
Nitric acid (70% or less)	3
Nitric acid (95%)	•
Nitrobenzene	43
1- or 2-Nitropropane	43
Nitrotoluene	43
Nonane	31
Nonene	30
Nonyl alcohol	20
Nonyl phenol	21
Nonyl phenol (ethoxylated)	40
Octane	31
Octene	30
Octyl alcohol	20
Octyl aldehyde	19
Octyl epoxytallate	34
Oils	
Clarified	33
Coal	33
Crude	33
Diesel	33
Edible oils, including	
Castor	34
Coconut	34
Cotton Seed	34
Fish	34
Lard	34
Olive	34
Palm	34
Peanut	34
Safflower	34
Soya bean	34
Tucum	34
Vegetable	34
Fuel Oils	
Nos. 1 (kerosene), 1-D, 2, 2-D, 4, 5, 6	33
Residual	33
Road	33
Transformer	33

Table B3-2. (Continued).

Name	Reactivity group No.
Miscellaneous oils, including	
Absorption	33
Aromatic	33
Coal tar	33
Heartcut distillate	33
Linseed	33
Lubricating	33
Mineral	33
Mineral seal	33
Motor	33
Neatsfoot	33
Penetrating	33
Range	33
Resin	33
Resinous petroleum	33
Rosin	33
Sperm	33
Spindle	33
Spray	33
Tall	33
Tanner's	33
Turbine	33
Oleum	•
Pentachloroethane	36
Pentadecanol	22
Pentane	31
Pentene	30
Pentyl aldehyde	19
Perchloroethylene	36
Petrolatum	33
Petroleum naphtha	33
Phenol	21
Phosphoric acid	1
Phosphorous	•
Phthalic anhydride (molten)	11
Polybutene	30
Polyethylene glycols	40
Polymethylene polyphenylisocyanate	12
Polypropylene	30
Polypropylene glycol methyl ether	40
Polypropylene glycols	40
Propane	31
Propanolamine	8
Propionaldehyde	19
Propionic acid	4
Propionic anhydride	11
Propyl acetate	34
Propyl alcohol	20
Propylamine	7
Propylene	30
Propylene butylene polymer	30
Propylene glycol	20
Propylene oxide	16

Table B3-2. (Continued).

Name	Reactivity group No.
Propylene tetramer	30
Propyl ether	41
Pyridine	9
Sodium hydrosulfide solution (45% or less)	5
Sorbitol	20
Styrene (inhibited)	30
Sulfolane	39
Sulfur (molten)	•
Sulfuric acid	2
Sulfuric acid, spent	2
Tallow	34
Tallow fatty alcohol	20
1,1,2,2-Tetrachloroethane	36
Tetradecanol	20
Tetradecene	30
Tetradecylbenzene	32
Tetraethylene glycol	40
Tetraethylenepentamine	7
Tetrahydrofuran	41
Tetrahydronaphthalene	32
Tetrasodium salt of EDTA acid solution	43
Toluene	32
Toluene diisocyanate	12
1,2,4-Trichlorobenzene	36
Trichloroethylene	36
Tridecanol	20
Tridecene	30
Tridecylbenzene	32
Triethanolamine	8
Triethylamine	7
Triethyl benzene	32
Triethylene glycol	40
Triethylenetetramine	7
Tripropylene glycol	40
Turpentine	30
Undecanol	20
Undecene	30
Undecylbenzene	32
Valeraldehyde	19
Vinyl acetate (inhibited)	13
Vinyl chloride (inhibited)	35
Vinylidene chloride (inhibited)	35
Vinyl toluene (inhibited)	30
Xylene	32

• Because of very high reactivity or unusual conditions of carriage, this product is not included in the compatibility chart.

Table B3-3. Reactivity groups and examples of chemical compounds contained in those groups.

Reactivity group No.	Name
1	Non-oxidizing mineral acids
	Hydrochloric acid
	Hydrofluoric acid
	Phosphoric acid
2	Sulfuric acids
	Spent sulfuric acid
	Sulfuric acid (98% or less)
3	Nitric acid
	Nitric acid (70% or less)
4	Organic acids
	Acetic acid
	Butyric acid
	Formic acid
	Propionic acid
	Acrylic acid (inhibited)
5	Caustics
	Caustic potash solution
	Caustic soda solution
	Cresylate spent caustic solution
	Sodium hydrosulfide solution (45% or less)
6	Ammonia
	Ammonia, anhydrous
	Ammonium hydroxide (28% or less)
	Ammonium nitrate, urea, water solutions (containing ammonia)
7	Aliphatic amines
	Butylamine
	Cyclohexylamine
	Dibutylamine
	Diethylamine
	Diethylenetriamine
	Diisopropylamine
	Dimethylamine
	Di-n-propylamine
	Ethylamine
	Ethylenediamine
	Hexamethyleneimine
	Methylamine
	Morpholine
	Propylamine
	Tetraethylenepentamine
	Triethylamine
	Triethylenetetramine
8	Alkanolamines
	Aminoethylethanolamine
	Diethanolamine
	Diethylethanolamine
	Diisopropanolamine
	Dimethylethanolamine
	Ethanolamine
	Propanolamine
	Triethanolamine
9	Aromatic amines
	Aniline
	Pyridine
	2-Methyl-5-ethylpyridine
10	Amides
	Dimethylformamide

Table B3-3. (Continued).

Reactivity group No.	Name
11	Organic anhydrides
	Acetic anhydride
	Phthalic anhydride
	Propionic anhydride
12	Isocyanates
	Diphenylmethane diisocyanate
	Polyphenyl polymethyleneisocyanate
	Toluene diisocyanate
13	Vinyl acetate
	Vinyl acetate (inhibited)
14	Acrylates
	Butyl acrylates
	Butyl methacrylate (inhibited)
	Decyl acrylate (inhibited)
	Ethyl acrylate (inhibited)
	2-Ethylhexyl acrylate (inhibited)
	Ethyl methacrylate (inhibited)
	Methyl acrylate (inhibited)
	Methyl methacrylate (inhibited)
15	Substituted allyls
	Acrylonitrile (inhibited)
	Allyl alcohol
	Allyl chloride
	1,3-Dichloropropene
16	Alkylene oxides
	Propylene oxide
	Butylene oxide
17	Epichlorohydrin
18	Ketones
	Acetone
	Camphor oil
	Cyclohexanone
	Diisobutyl ketone
	Isophorone
	Mesityl oxide
	Methyl ethyl ketone
	Methyl isobutyl ketone
19	Aldehydes
	Acetaldehyde
	Acrolein (inhibited)
	Butyraldehyde
	Decaldehyde
	Ethylhexaldehyde
	Formaldehyde
	Glutaraldehyde solution
	Glyoxal solution
	Methylbutyraldehyde
	Octyl aldehyde
	Pentyl aldehyde
	Propionaldehyde
	Valeraldehyde
20	Alcohols, glycols
	Amyl alcohol
	Butyl alcohol
	1,3-Butylene glycol
	Cyclohexanol
	Decyl alcohol
	Diacetone alcohol
	Diisobutyl carbinal

Table B3-3. (Continued).

Reactivity group No.	Name
	Dodecanol
	Ethanol
	Ethoxylated alcohols C11—C15
	Ethyl alcohol
	Ethylbutanol
	Ethylene chlorohydrin
	Ethylene cyanohydrin
	Ethylene glycol
	2-Ethyl hexanol
	Furfuryl alcohol
	Glycerin
	Hexanol
	Hexylene glycol
	Methanol
	Methyl alcohol
	Methyamyl alcohol
	Methylisobutyl carbinol
	Octyl alcohol
	Nonyl alcohol
	Pentadecanol
	Propyl alcohol
	Propylene glycol
	Sorbitol
	Tallow fatty alcohol
	Tetradecanol
	Tridecanol
	Undecanol
21	Phenols and cresols
	Carbolic oil
	Creosote, coal tar
	Cresols
	Nonyl phenol
	Phenol
22	Caprolactam solution
23 to 29	Unassigned
30	Olefins
	Butadiene (inhibited)
	Butene
	Butylene
	Decene
	Dicyclopentadiene
	Diisobutylene
	Dodecene
	Ethylene
	Hexene
	Isoprene (inhibited)
	Methyl acetylene, propadiene mixture (stabilized)
	(Alpha-)Methyl styrene (inhibited)
	Nonene
	Octene
	Pentene
	Polybutene
	Polypropylene
	Propylene
	Propylene butylene polymer
	Propylene tetramer
	Styrene (inhibited)
	Tetradecene
	Tridecene
	Turpentine

Table B3-3. (Continued).

Reactivity group No.	Name
	Undecene
	Vinyl toluene (inhibited)
31	Paraffins
	Butane
	Cycloaliphatic resins
	Cyclohexane
	Decane
	Dodecane
	Ethane
	Heptane
	Hexane
	Methane
	Nonane
	Octane
	Pentane
	Propane
32	Aromatic hydrocarbons
	Benzene
	Benzene, toluene, xylene (crude)
	Cumene
	Cymene
	Decylbenzene
	Diethylbenzene
	Dodecylbenzene
	Ethylbenzene
	Naphthalene
	Tetradecylbenzene
	Tetrahydronaphthalene
	Toluene
	Tridecylbenzene
	Triethylbenzene
	Undecylbenzene
	Xylene
33	Misc. hydrocarbon mixtures
	Asphalt
	Asphalt blending stocks
	Diphenyl-diphenyl oxide
	Distillates
	Gas oil, cracked
	Gasoline blending stocks
	Gasolines
	Jet fuels
	Kerosene
	Mineral spirits
	Naphtha
	Oils, crude
	Oils, diesel
	Oils, coal
	Oils, fuel (No. 1 through No. 6)
	Oils, residual
	Oils, road
	Oils, transformers
	Petrolatum
	Petroleum naphtha
34	Esters
	Amyl acetate
	Amyl tallate
	Butyl acetate
	Butyl benzyl phthalate
	Castor oil

Table B3-3. (Continued).

Reactivity group No.	Name
	Coconut oil
	Cottonseed oil
	Dibutyl phthalate
	Diethylene glycol monobutyl ether acetate
	Diheptyl phthalate
	Diisodecyl phthalate
	Dinonyl phthalate
	Dioctyl phthalate
	Diundecyl phthalate
	Ethyl acetate
	Ethylene glycol monobutyl ether acetate
	Ethylene glycol monoethyl ether acetate
	Ethylhexyl tallate
	Fish oil
	Glycol diacetate
	Lard
	Methyl acetate
	Methyl amyl acetate
	Octyl epoxy tallate
	Olive oil
	Palm oil
	Peanut oil
	Propyl acetate
	Safflower oil
	Soybean oil
	Tallow
	Tucum oil
	Vegetable oil
35	Vinyl halides
	Vinyl chloride (inhibited)
	Vinylidene chloride (inhibited)
36	Halogenated hydrocarbons
	Carbon tetrachloride
	Chlorobenzene
	Chloroform
	Dichlorobenzene
	1,1-Dichloroethane
	Dichloroethyl ether
	Dichloromethane
	1,1-Dichloropropane
	1,2-Dichloropropane
	Ethyl chloride
	Ethylene dibromide
	Ethylene dichloride
	Methyl bromide
	Methyl chloride
	Pentachloroethane
	Perchloroethylene
	1,1,2,2-Tetrachloroethane
	1,2,4-Trichlorobenzene
	Trichloroethylene
37	Nitriles
	Acetonitrile
	Adiponitrile
38	Carbon disulfide
39	Sulfolane
40	Glycol ethers
	Diethylene glycol
	Diethylene glycol monobutyl ether
	Diethylene glycol monoethyl ether

Table B3-3. (Continued).

Reactivity group No.	Name
	Diethylene glycol monomethyl ether
	Dipropylene glycol
	Ethoxy triglycol
	Ethylene glycol monobutyl ether
	Ethylene glycol monoethyl ether
	Ethylene glycol monomethyl ether
	Nonylphenol, ethoxylated
	Polyethylene glycols
	Polypropylene glycols
	Polypropylene glycol methyl ether
	Soybean oil, epoxidized
	Tetraethylene glycol
	Triethylene glycol
	Tripropylene glycol
41	Ethers
	Butyl ether
	1,4-Dioxane
	Ethyl ether
	Methyl formal (dimethyl formal)
	Propyl ether
	Tetrahydrofuran
42	Nitrocompounds
	(Mono-)Nitrobenzene
	1- or 2-Nitrobenzene
	Nitrotoluene
43	Miscellaneous water solutions
	Ammonium nitrate, urea, water solutions (not containing ammonia)
	Corn syrup
	Dextrose solution
	Latex solution
	Tetrasodium salt of EDTA solution

ATTACHMENT 2

WEEKLY INSPECTION CHECKLIST

WASTE ACCUMULATION AREA

Date ____________ Bldg ____________ Inspector ____________________

Time ____________

General

Yes	No*	
______	______	Area posted with appropriate hazard and cautionary signs.
______	______	Area free of spills.
______	______	Secondary containment basin free of liquid and debris.
______	______	Emergency equipment present and in operating condition.
______	______	Proper use of Hazardous Waste Management requisition form.
______	______	Current contingency plan posted.

Containers

Yes	No*	
______	______	All containers labeled with <u>completed</u> and <u>dated</u> Hazardous Waste Labels.
______	______	No waste containers present over the 90-day storage limit. Note: If any waste containers are over the 90-day storage limit, contact your Environmental Analyst immediately.
______	______	Containers compatible with waste being stored.
______	______	Containers closed except when adding wastes.
______	______	Containers in good condition, free of leaks and deterioration.
______	______	Adequate separation of incompatible waste.
______	______	Ignitable waste isolated from sources of ignition and at least 50' from property line (perimeter fence).

* Describe corrective action needed

____

____

____

____

____

Date corrective action completed: ______________________

88-188

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 501 10/11/91

FIRING RANGE OPERATIONS - BUILDING 899

A. INTRODUCTION

Building 899 and the surrounding area provide practice ranges for the training of personnel in the use of firearms. The firing range is operated by the Protective Force Division of the Safeguards and Security Department.

B. SCOPE

This procedure is applicable to all operations and personnel at the Firing Range Facility and supplements the LLNL Health and Safety Manual. Occasional use of these ranges by non-LLNL Security personnel is permitted on approval of the LLNL Security Manager and the Site 300 Resident Manager with the agreement that all provisions of this procedure will be complied with. Non-LLNL users must first read and sign the Management's range use agreement form (Hold Harmless and Agreement to Defend).

This procedure establishes the safety requirements, danger zones and conditions for range use. All operations not complying with this procedure require a supplemental Operational Safety Procedure (OSP).

All operations at the firing range shall comply with DOE 5480.16 ("Firearms Safety").

All LLNL users of the firing range shall be familiar with this procedure and the range safety rules. Whenever this procedure or the range safety rules are revised, each user will be familiarized with the new version.

C. HAZARDS ANALYSIS

Operations at the firing ranges present risks to personnel involved in weapons training as well as to LLNL and non-LLNL personnel adjacent to the range. The maximum credible accident involves a stray or ricochet round striking exposed explosives or incapacitating an explosives driver resulting in an explosion/fire with injury and property damage. A more probable accident would be personnel injury by a stray/ricochet round to a LLNL or non-LLNL individual. Both ranges are laid out using the criteria contained in DARCOM R-385-100, Chapter 28 and have the required safety zones and warning devices for the specific weapons to be fired. The controls outlined below will eliminate or adequately control the discussed risks.

NOTE: This procedure has been completely revised.

FIRING RANGE OPERATIONS - BUILDING 899

D. RESPONSIBILITIES

1. The Range Master has primary responsibility for the firing range.
   a. The Range Master (an employee assigned by the Protective Force Division) is responsible for assuring that all operations are performed in conformance with this procedure, DOE 5480.16, other pertinent Site 300 Procedures and the LLNL Health and Safety Manual.

   b. In his absence a designated alternate shall assume full responsibility. The Range Master or a designated alternate will be present during all firing activities to enforce this procedure.

2. The Range Master shall:
   a. Provide safety direction and guidance in the transportation, storage, handling and operation of weapons and munitions used on the range and shall control all personnel and activities on the range when firearms are present.

   b. Identify, analyze and evaluate a variety of hazards involving the use of ammunition, explosives or chemical devices used in live fire training exercises.

   c. Verify range safety data and/or protective containment construction requirements through on-site inspection, interpretation and use of surface danger zones and maps.

   d. Assess risk to personnel conducting range operations and recommend safety measures consistent with training requirements.

3. A Safety Officer or an instructor with specific delineated responsibilities for range safety shall:
   a. Be present during all firearms training activities.

   b. Not be assigned instructional duties unless approved by the Range Master.

E. WEAPONS AND AMMUNITION CONTROLS

1. Weapons Permitted to be fired on the range are:

   a. 50 Yard Range

   Hand guns and shoulder weapons. Shoulder weapons include shotguns and H&KMP5 SD.

   b. 300 Meter Range

   Weapons including AR-180, M-16, H&K33KE, H&K53A2 and Remington 700 BDL in full automatic mode and semiautomatic mode.

   NOTE: Thirty caliber machine guns are not permitted to be fired on any of the ranges due to the lack of space required for safety zones.

2. Army Regulation 385-63 applies to firing range operations conducted at DOE Facilities. Firing of the H&K33KE and H&K53A2 weapons at the 300 meter range is in conformance with AR 385-63 because these weapons have a maximum range of 2,874 meters. The 300 meter range is in a path extending to the Site 300 property line at a minimum distance of 2,900 meters. This procedure complements the distance criteria of AR 385-63 because the following conditions and operating regulations will reduce the risk to an acceptable safe level:

   a. The terrain is hilly providing a barrier.

   b. The targets are in a fixed position.

   c. The HK33 and 53A2 will be fired from prone kneeling and standing position.

   d. A surface danger zone of 10° from the gun target line will be strictly enforced by the Range Master.

3. Simultaneous operation of the ranges is not permitted unless two designated Safety Officers or instructors with specific delineated responsibilities for range safety are present to coordinate the activities.

E. WEAPONS AND AMMUNITION CONTROLS: cont'd

4. Small arms ammunition (20 mm and smaller) and shotgun shells are defined as LLNL Type O Explosives (see Site 300 Safety and Operational Manual, Procedure No. 112). A maximum of 20,000 rounds may be stored at the range.

5. Larger caliber ammunition is classified as LLNL Type X Explosives and storage is not permitted at the range. Only quantities sufficient for one day's training will be brought to the range and excess returned to magazine storage.

6. No personal hand loaded ammunition will be used on the range.

7. Tracer ammunition is not permitted on any of these ranges because of wild land fire danger.

8. Misfired or bent small arms ammunition will be collected and placed in boxes labeled "duds."

F. OPERATIONAL CONTROLS

1. The ranges will be used only for the weapons described in Section E.

2. A communications system with backup shall be available at the live-firing range. Building 899-A has a portable Motorola handheld which will be taken to the rifle range whenever activated. There are three telephones located at the live firing range. One is located in Building 899-B, one in Building 899-A cleaning room and one is hanging outside of Building 899-A.

3. Only approved steel targets shall be used. Other exposed metals, i.e., target stands, shall be protected, configured or constructed so as not to expose personnel to potential ricochet.

F. OPERATIONAL CONTROLS - cont'd

4. For range use, the Range Master will:

   a. Notify the Site 300 Police Console via telephone, Ext. 3-5222, prior to range house entry.

   b. Inform the Police Console that the range is open and firing will be in progress.

   c. Raise the red flag (flagpole at main entrance gate and Southwest corner of range) prior to commencement of firing. For night firing, activate the flashing red light on the Range House. If it is ever credible that live fire operations may affect aircraft operations, the FAA or the authorized aviation operations center shall be notified of schedules and activities.

   d. Reverse above procedure to secure range.

   e. Follow the specific range safety rules as listed in Appendix A.

   f. Prior to the implementation of any new training or evaluation method involving firearms, a risk analysis shall be completed.

   g. Sufficient lighting shall be available to assure safe nighttime firing exercises. Two-foot candles are recommended as a minimum.

5. The cleanliness of the range is the responsibility of user personnel. All equipment, targets and empty cases are to be placed in the Range House (Building 899) prior to securing the range.

6. Airborne lead concentrations shall be measured in compliance with OSHA Standard 1910.1025.

7. Firearms instructors shall be given blood test for lead in conformance with OSHA Standard 1910.1025.

8. All employees involved in regular firearms training shall be given annual hearing tests.

9. Steel targets shall be examined prior to every use. Targets that bow in excess of 10 degrees and/or contain dimples in excess of one-sixteenth of an inch in depth shall be removed from use.

FIRING RANGE OPERATIONS - BUILDING 899

G. PERSONNEL CONTROLS

1. The Range Master or certified Range Instructor will be present during any firing operations. Before firing commences, a safety briefing for all participants shall be conducted including range safety rules, capabilities of the weapons to be used and safe operating procedures for the course of fire to be undertaken.

2. A visual inspection of the immediate impact area will be conducted by the Range Master, Instructor or Range Safety Officer prior to any live fire. Signs will be permanently installed on all fire trails leading into the downrange hazard area as well as around the perimeter of the impact fans, as required by AR 385-63. These signs will warn personnel that they are entering a potentially hazardous area and require that they check with the Site 300 Police Console (MIKE) for approval before proceeding. The Range Master, Instructor or Range Safety Officer will check the condition and location of these signs at least once each quarter. (See Appendix B for a map of the approximate locations of the hazardous area.

3. All personnel (including non-LLNL personnel) are required to use muffs to protect their hearing. Earmuffs will be cleaned with the provided cleaner by the user at the end of daily operation.

4. All personnel are required to use eye protection while using the range.

5. Eating, drinking or smoking is prohibited in areas where weapons are fired or cleaned. Always wash hands after firing/cleaning a weapon and before eating, drinking or smoking.

6. All bystanders and observers are required to stand behind the 50 yard line at the live-fire range, unless given permission by the Range Master, Instructor or Range Safety Officer to proceed closer. Personal protective and safety equipment and procedures in effect at the range shall be complied with.

7. Handling weapons in the classroom will only be done at the direction of the Range Master, Instructor or Range Safety Officer. In the event that a weapon needs to be drawn from the holster in the classroom, the student or instructor will stand directly in front of the bullet trap and draw his/her weapon, pointing the muzzle at the bullet trap. The student or instructor will then open the cylinder of the weapon to ensure that it is unloaded. The bullet trap meets the specifications set forth by DOE Central Training Academy and was constructed at Site 300.

G. PERSONNEL CONTROLS - cont'd

8. There is only one designated parking area for private vehicles at the Small Firearms Training Facility (SFTF). A sign directing individuals to the proper parking area is located approximately 50 yards from the main entrance to the SFTF. The designated parking area is identified by several signs marked "parking". There are three roads leading out of the parking area which are clearly marked "Government vehicles only beyond this point. Check in with the office before leaving". No private vehicles are allowed beyond these points.

H. EMERGENCY PROCEDURES

1. Emergency response will be in accordance with the Building 899 Emergency Response Plan.

2. Personnel injuries or hazardous conditions are to be immediately reported to the Site 300 Police Console (Emergency Dispatcher for Site 300), 423-5333.

3. The Range Master, the Range Safety Officer and designated Firearms Instructor shall review and be familiar with the Emergency Section of the Site 300 Operational and Safety Manual before beginning their duties on the range.

4. Emergency response drills shall be carried out at least annually to test personnel preparedness in implementing the plan (DOE 5480.16, Chapter I.4.i., Page I.7).

5. The live firing range has two first aid kits. Both kits are equipped with materials to handle first aid and gunshot wounds. These kits shall be inspected on an annual basis by the Site 300 Medical staff. One kit is stored in Building 899-B. The other kit is stored at the rifle range. One backboard and three blankets are located in Building 899-A.

6. In the event of an accident or injury at the live firing range, the Fire Department will be notified by radio or telephone (423-5333). If the Fire Department determines that medi-flight is needed, they will inform the proper authorities that the range is approximately two miles west of the main entrance to Site 300 on Corral Hollow Road and across the street from Carnegie State Vehicle Recreation Area. The helicopter crew will determine the safest place to land.

FIRING RANGE OPERATIONS - BUILDING 899

REVIEWED BY:

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Site 300 Resident Manager

APPENDIX A

RANGE SAFETY RULES

1. Unless engaged in an approved course of fire, never handle, point or look over the sights of a firearm without first opening the cylinder and/or action to be sure that it is not loaded and only then under the direction of the Range Master, Range Safety Officer or Firearms Instructor.

2. Weapons shall not be left unattended or unsecured.

3. Never point a weapon at anything you do not intend to shoot.

4. Obey all range commands immediately. Instantaneous response insures the safety of all shooters present.

5. When automatic or semiautomatic weapons are being fired, shooters shall take precautions to prevent hot brass and gun shot residuals from getting inside of clothing.

6. Do not speak to anyone while on the firing lines except range personnel or an appointed, qualified coach.

7. Do not leave the firing line with a loaded weapon.

8. In the event of a misfire or weapon malfunction, keep weapon pointed at target. Immediately call for the Range Master, Range Safety Officer or a Firearms Instructor to open the weapon. **DO NOT UNLOAD THE WEAPON YOURSELF.**

9. Weapons will be loaded only after position is taken on the firing line and after the command **LOAD** has been given by the range official running the firing line. Until the firing line has been declared safe by the firing official, shooters shall not bend over or move over the firing line.

10. Always examine the weapon for any obstruction before loading.

11. Ascertain the backstop, target and area beyond to the extent of the weapons range are clear.

12. Do not dry-fire a weapon except when so directed by the Firearms Instructor as an instructional practice.

APPENDIX A

RANGE SAFETY RULES

13. All weapons will be either holstered or be so placed so that the barrel is pointing downrange at all times.

14. **NEVER** hand a weapon to anyone unless it is unloaded, action open and not pointing at another person.

15. Whenever a weapon is handed to you, always check to make sure it is unloaded. **NEVER** assume or take someone's word that it is not loaded.

16. The only time you should ever carry a loaded weapon in a holster on the range is in the course of firing an approved course of fire.

17. Authorized targets will be supplied by the Training Officer. Non-LLNL users will provide similar authorized targets. The shooting of random targets, cans, bottles, etc., is prohibited.

18. Alcohol beverages and drugs are prohibited on the firing range. Shooters taking medication shall report this fact to the staff before reporting to the firing line.

19. Eating, drinking and smoking are prohibited while on the firing line.

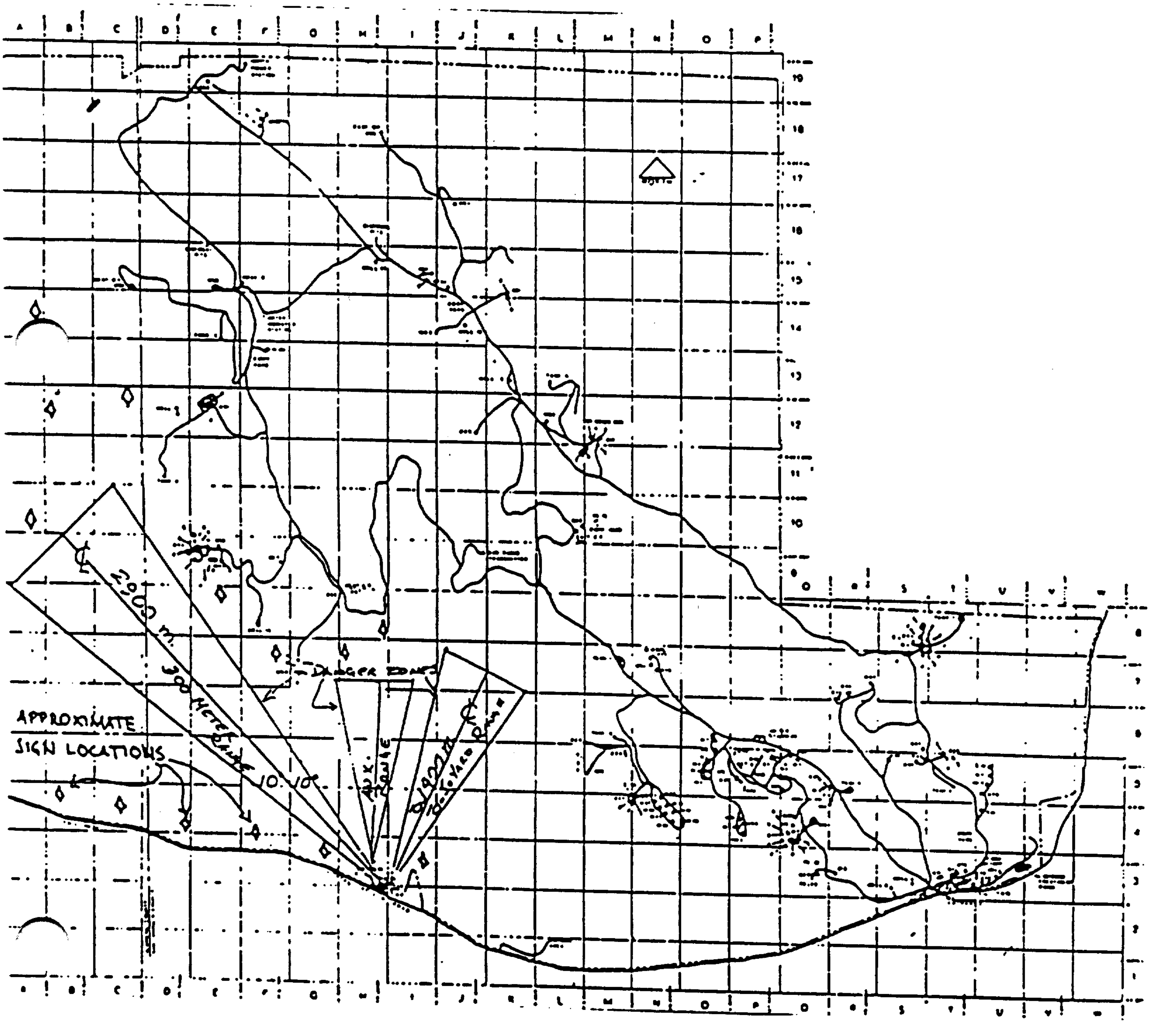
20. **MAKE SAFETY A HABIT.** There are no accidents with firearms. "Range accidents" are actually due to violations of range rules and a lack of common sense. While on the range, do three things: know the rules, follow the rules and most important, **THINK.**

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 501 10/11/91

APPENDIX B

FIRING RANGE WARNING SIGNS



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LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 600   6/8/93

DEFENSE TECHNOLOGIES ENGINEERING DIVISION FACILITIES

A. GENERAL

The facilities, operated by Defense Technologies Engineering Division (DTED) of Mechanical Engineering, are used for the static, dynamic and physical properties testing of explosives, mock HE, toxic and radioactive materials. In test units, wherein the use of combinations of materials specified by the design would unacceptably increase the hazards, inert materials are substituted.

B. SCOPE

This procedure is applicable to all operations in the DTED facilities at Site 300. The safety regulations in this procedure supplement the LLNL Health and Safety Manual and apply to all participants or visitors to these facilities. Each facility also has an individual procedure covering the specific operations at that facility. See these procedures for details.

C. HAZARD ANALYSIS

Explosives in the form of test specimens, components, billets and larger amounts in test items are tested in the DTED facilities. In many of the thermal and dynamic tests, there is a possibility of putting sufficient energy into the test to initiate a reaction in the explosives. Personnel controls in the form of gates, personnel barricades and locked doors are used to prevent personnel from entering areas of high risk of injury. Tests with a moderate to high risk of reaction in the explosives are done remotely. Remote operations are controlled from a central control room, which is also a protected location for blast and fragments. The controls stated in this procedure and the remaining procedures in the 600 series will limit potential risk to personnel injury, building and environmental damage from accidental explosions.

D. RESPONSIBILITIES

1. DTED Group Leader

The DTED Group Leader or his alternate is responsible to insure that all operations are done safely and in compliance with existing procedures.

2. Test Engineer

The engineer responsible for a test shall submit the following items to the DTED Technician Supervisor for review by Hazards Control and other appropriate groups.

a. DTED Group test plan or test request.

b. Associated assembly drawings.

c. Associated classified documents.

d. A draft Operational Safety Procedure (OSP), when required by the procedure, or the specific procedure controlling each facility, the Health and Safety Manual or the Environmental Protection Handbook. In the event the scope of the test plan changes, the Test Engineer shall submit to Hazards Control a revised OSP describing the proposed changes. These changes shall be reviewed and approv by the method described in Chapter 2 of the Health and Safe Manual before the change is implemented.

3. DTED Technician Supervisor

The DTED Technician Supervisor or his alternate is responsible for the safety of the operations in his area. The DTED Technician Supervisor shall maintain a list of building operators and alternates.

E. MATERIAL CONTROLS

The material controls are defined in each specific facility procedure.

F. OPERATIONAL CONTROLS

1. Electrical

a. Although the electrical wiring and equipment in the test cells of these facilities must meet the requirements of the NEC Class II, Division 1, Group G, operations in these facilities are not classified as a "hazardous location" as defined in Article 500 of the NEC, since no explosive dusts are generated (see E.2.b). General purpose electric wiring and equipment are normally prohibited in these facilities minimize the risk of electrical fires in the explosives handling area.

b. Each application of electrical heaters on a test unit containing explosives shall be approved by an OSP.

c. All instrumentation directly applied to explosives in a test item must be either visibly disconnected, isolated or grounded (except for those instrumentation channels which are intrinsically safe) before personnel enter the test cell.

d. Environmental control transducer leads, not attached to the test item and permanently installed in an approved control system, need not be grounded or disconnected.

e. Special temporary equipment and/or cabling required for tests shall be installed in a manner consistent with the above safety procedures after consultation with the supervisor.

f. When explosives are present in a test cell, all electrical power higher than 120 volts to that test cell must be unpatched or positively locked out before personnel entry to that cell is made. The lockout key must be in the possession of the facility personnel entering the cell.

2. Explosives

a. Explosives or explosives contaminated material shall not be permitted in any part of the facilities other than explosives test cells or the drop tower.

b. No operation that generates airborne explosives dust or powder (i.e., drilling, machining, sawing or sanding explosives) is permitted. Also, no operation which requires blending or mixing of explosives with other materials, such as plastic, binders, glues, adhesives or metal dusts, is permitted.

c. Handling "HOT" Explosives

During thermal conditioning of explosives, personnel shall not use bare hands to manipulate explosives samples above 49^{o}C (120^{o}F). This will prevent burning the hands and dropping test items. With thermal hand protection approved by the DTED Technician Supervisor, visual inspection, handling of tensile and compressive specimens, depth and gap measurements, axis changes inside thermal chambers, instrumentation repairs and photographs are permitted at temperatures up to 77°C (170°F) only with LLNL Type A or UNO Compatibility Group D explosives. At temperatures above 170°F, the safety properties of even Type A or UNO Compatibility Group D explosives are not well known. Handling any explosive at temperatures above 170°F shall be reviewed by Site management and an OSP prepared to authorize the operation.

3. Testing

a. All operations of a hazardous nature involving explosives will be conducted remotely with the pertinent cell door locked and gate closed or chain barriers up. Additionally, the rotating red beacon shall be operating and signs posted which indicate no entry is permitted within the closed gate area or behind the chain barriers. Some tests will require a personnel muster to be called. At any time, when the test is in a static nonhazardous condition, only the cell door needs to be locked.

d. Conditions which require remote operation:

(1) All test items whose electrical systems are outside the guidelines set up in this procedure.

(2) All operations where LLNL Type A or UNO Compatibility Group D explosives are at a temperature in excess of 77° C (170°F).

(3) Any test involving mechanical shock or extrusion to explosives.

(4) Any test in which the Facility Operator feels the safety or personnel is in doubt.

c. If during any phase of a test the Facility Operator notes that abnormal conditions of a potentially hazardous nature exist, testing shall be stopped and he shall call the DTED Technician Supervisor. The latter will consult with the Hazards Control ES&H Team Leader and they jointly will make judgment as to what course of action to follow.

d. The status of the test cells shall be reflected in the daily status report of the facility. (See Procedure No. 124 for guidance.)

4. Containers

Fixtures, vessels and containers must be proof-tested using mock components if there is any question as to their complete reliability before actual live runs can be performed with explosives. The Test Engineer shall inform Hazards Control of the outcome of these tests.

5. Radiation Monitoring

a. All Tests

A Hazards Control Health and Safety Technician shall check for contamination when a test unit containing radioactive materials is removed from the shipping container, at the completion of all tests and when packaged for shipment from Site 300.

b. Dynamic Tests

Dynamic tests containing radioactive materials are normally conducted in Livermore at Building 334. Before any dynamic tests are conducted on unit containing radioactive materials at Site 300, the Test Engineer will contact the ES&H Team Leader to review specific requirements for radiation monitoring.

6. Disassembles

No disassembly of a test item containing explosives or any other hazardous material may take place until an OSP has been prepared, approved and distributed.

G. PERSONNEL CONTROLS

1. Smoking and consumption of food or beverages shall be permitted only in posted areas.

2. All matches and/or spark-producing instruments will be deposited in receptacles provided at the entrance to the explosives work areas.

3. LLNL issued safety shoes or booties shall be worn in the explosives test cells when requested by the Facility Lead Operator or his alternate.

DEFENSE TECHNOLOGIES ENGINEERING DIVISION FACILITIES

4. The movement of personnel into a hazardous area during REMOTE operations shall be prevented by using safety warning signs and lights and one or more of the following:

    a. By hanging chain barriers.

    b. By closing road or fence gates.

    c. By locking personnel doors to test cells.

5. Permission must be obtained from the supervisor or his alternate before entering a test area if conditions require the gate to that area to be closed or a chain barrier to be erected.

6. Personnel shall not be permitted in the test cell and adjoining hazardous areas during remote testing of specimens containing explosives or other hazardous materials.

7. While explosives handling or testing is in progress, personnel will be kep at a minimum needed for experimental requirements. The minimum shall be two persons at the facility, one of whom must be qualified in the DTED Group's explosives operations.

8. During lightning alert conditions, personnel in the facilities will seek shelter in the following protected locations assuming that explosives are present in the building or complex:

    - 834 Control Room
    - 836 Control Room
    - 854 Control Room
    - 855 Control Room
    - 858 Control Room

    The preceding is general guidance for personnel response to lightning alerts. For more specific guidance during a lightning alert, refer to Procedure No. 102 and contact the Site 300 DTED Group Supervisor or his alternate or Hazards Control.

H. TRAINING

All personnel who generate or handle hazardous waste shall attend the Environmental Protection Department's course, EP-0006, "Hazardous Waste Handling Practices", six months after being newly hired and annually thereafter.

I. ENVIRONMENTAL CONCERNS

Any hazardous waste will be handled according to the policies and practices outlined in EP-0006 training, "Hazardous Waste Handling Practices". All waste will be taken to the Building 834 WAA.

J. EMERGENCY ACTION

See the Emergency Section (Section E of this manual) for proper action during an emergency.

DEFENSE TECHNOLOGIES ENGINEERING DIVISION FACILITIES

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DTED Group Leader

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Site 300 Resident Manager

LAWRENCE LIVERMORE NATIONAL LABORATORY - SITE 300

Procedure No. 700 6/24/91

CHEMISTRY AREA OPERATING PROCEDURE
BUILDINGS 825, 826 AND 827 COMPLEX

*A. GENERAL

This area is operated by the Energetic Materials Section of the Chemical Sciences Division of the Chemistry and Materials Science Department for the purpose of processing, developing and testing explosives.

B. SCOPE

This procedure, Section 1 and the Emergency Section of the Site 300 Safety and Operational Manual provide general guidance to all personnel for operations within the Chemistry Area. Procedure No. 701 describes the Chemistry Job Summary and the remaining procedures in Section 7 give operating details for specific equipment and cells.

C. HAZARDS ANALYSIS

1. General

Principle hazards are personnel exposure when handling explosives, propellents, pyrotechnics and oxidizers. These materials can be initiated to burn or detonate by any of the common types of energy input. Impact, frictional heat or sparks, heat, shock, electric arcs or sparks from static electricity may ignite these materials unless properly controlled. Since the threshold of ignition in terms of energy input for any material is not well defined, each operation must be conducted in a manner that has been carefully analyzed to assure its safety.

The toxic nature of some explosives may also present a personnel hazard when they are handled. Personnel exposure can result from inhalation of dusts or vapors, absorption by skin contact or ingestion during normal handling. Information on toxicity must be known so that required controls can be applied.

2. Exemption from Mandatory Standard

DOE-SAN has granted an exemption to the two exit requirements in the DOE Explosives Safety Manual for Building 827, Cells C, D and E, because the second exit would not significantly reduce the risk of personnel injury. This exemption dated April 17, 1985, will remain in effect until the use or condition in these cells changes. A copy of this exemption is on file with Hazards Control Explosives Safety, the Facility Supervisor and the Site 300 Resident Manager.

*Revised

*D. RESPONSIBILITIES

*1. Facility Manager

The Site 300 Facility Managers for Energetic Material Section duties include the following:

*a. Make certain that all work performed complies with all appropriate procedures.

b. Schedule experiments with safe and efficient use of the facility and personnel.

c. Review all operations and equipment prior to use and periodically review existing operations and facilities for safe and efficient operation.

d. Assign an operator to be in charge of each job.

*e. Ensure that each worker and each visitor knows the required safety practices for the operation in which he is involved.

*2. Operator-in-Charge

The Operator-in-Charge is responsible for safe and efficient operation of the specific job to which he is assigned. Facility users regardless of "rank" are subject to the rules and procedures for which the Operator-in-Charge is responsible. His responsibilities include the following:

a. Obtain materials and equipment for the job.

b. Ensure the equipment is in safe and efficient operating condition.

*c. Make certain that the work performed complies with all appropriate procedures.

3. Job Requestor

The Job Requestor is responsible for submitting an approved Chemistry Job Summary or Prior Approval (827-A Lab Operations listed in Procedure No. 721) which is required to perform any operation within the Chemistry Facilities. (See Procedure No. 701.)

*Revised

CHEMISTRY AREA OPERATING PROCEDURE
BUILDINGS 825, 826 AND 827 COMPLEX

E. MATERIAL CONTROLS

Any explosive listed on the approved Chemistry Job Summary or Prior Approval is authorized in these facilities (see Procedure No. 701). Quantities shall be kept to the minimum to complete each job and shall not exceed the maximum explosives weight limits given below:

Facility	Wt/Cell (lb)	Vault (lb)	Total Wt (lb)
827-A Lab	---	---	1/4
827-C	100	100	300
827-D	100	100	300
827-E	100	100	300
825	15	---	30
826	15	---	30
M-5	---	---	2,500
M-33	---	---	1,000
M-36	---	---	10,000
M-51	---	---	1,000
M-825-2	---	---	25
M-825-3	---	---	25
M-825-4	---	---	25
M-825-5	---	---	25
M-825-6	---	---	50
M-826-1	---	---	100
M-826-2	---	---	100

*The weight limit in operating buildings, only, may be doubled under the conditions described in F.1.d.

F. OPERATIONAL CONTROLS

1. General

a. All equipment shall be set up and checked to see if it is in good working order before processing explosives. This shall be done before the explosives are brought into a processing cell.

*b. Any change or exception to a procedure (including job summaries) relating to the safety of the operation, shall be approved by all persons who signed the procedure, summary or prior approval.

*Revised

*F. OPERATIONAL CONTROLS - cont'd

1. General - cont'd

c. When explosives are being weighed, packaged or transferred, no other operation in that cell or remote operation in an adjacent cell is authorized. A contact operation in an adjacent cell is permissible providing that the building load limit is not exceeded.

*d. Packages of explosives weighting up to twice the cell limit may be brought to the cell for the purpose of removing a required amount of explosive. The package with the remaining explosive must be removed from the cell prior to further processing of explosives.

e. Explosive processing cells and waste trenches shall be thoroughly washed down at the end of the day's operation. Collection traps shall be cleaned out as required to prevent any explosives buildup.

*2. Remote Operation

a. During remote operation, the gates to the particular building shall be closed and an appropriate warning sign shall be posted at each gate. In addition, the red rotating beacon in the area shall be activated. This applies to both regular and off-shift operations.

b. Entry into the cell after remote processing has been started shall be allowed only after the Operator-in-Charge has locked the local/remote selector switch in the off position and has removed the key. The key shall remain in his possession until all personnel have returned to the control room.

c. Unless specifically covered by a separate Chemistry Job Summary or OSP, no personnel shall be present in Building 827-C, -D or -E during a remote operation in that building, i.e., while equipment is being operated remotely. In Buildings 825 and 826, all personnel must be in the control room during remote operations.

*d. If for any reason it becomes necessary to enter the cell due to an equipment malfunction, the Site 300 Chemistry Facility Manager or his alternate shall be called to the area. The circuit breaker supplying power to the piece of machinery shall be disconnected before anyone is permitted to enter the cell.

*Revised

*F OPERATIONAL CONTROLS - cont'd

2. Remote Operations - cont'd

*d. The Site 300 Chemistry Facility Manager or his alternate shall decide whether an unsafe condition is likely. If an unsafe condition is likely, comply with Section H. If no safety problem is likely, the Site 300 Chemistry Facility Manager or his alternate may decide on appropriate remedial action.

e. The mechanical rooms for Buildings 825 and 826 shall be considered as restricted areas. Access to these areas during remote operations shall be limited to members of the operating crew making adjustments necessary for the operation.

3. Off-Shift Operations

a. If explosives processing extends beyond the normal shift, the Protective Force Division will be notified by way of the "Hazardous Operations Status Report". When the processing is completed, operating personnel shall notify the Protective Force Division of their departure.

b. Some operations, such as drying explosives in ovens, may be done unattended. These operations may extend beyond the normal shift and may be shut down by Maintenance Mechanics. Special instructions shall be given to the Maintenance Mechanics. These will be of the nature of turning on or off switches, valves, etc., in the mechanical equipment room or in the control room. At NO time shall these instructions require the Maintenance Mechanics to perform any operation in other than these two rooms.

c. Work at the 827-C, -D and -E Buildings and M-5 shall be limited to daylight hours or the electrical power to the exterior overhead lights will be turned off manually prior to moving explosives in or out of the building (reference Waiver No. 25-A).

*Revised

F. OPERATIONAL CONTROLS - cont'd

4. Electrical Equipment

*Any electrical apparatus or fixture which does not conform to the electrical classification of the facility as specified in Procedure No. 700, Appendix A, shall require authorization from the Site 300 Chemistry Facility Manager and Hazards Control prior to installation or use. The nonconforming electrical equipment approved for use shall be labeled by Hazards Control with an Electrical Authorization tag. This tag specifies any controls that may be required and is signed by the Site 300 Chemistry Facility Manager or alternate and Hazards Control.

5. Maintenance, Repair and Modifications

Work of this type shall be performed in conformity with Procedures Nos. 100, 115 and 203.

G. PERSONNEL CONTROLS

1. Personnel Controls

a. Personnel limits during operations and explosives weight limits are posted at each processing cell. The responsibility for the control of these limits rests with the Operator-in-Charge. The following personnel limits are to be followed:

Bay/Cell Number	Personnel Limit
827-C, -D & -E Vaults	2
825 & 826 Cells & 827-A Lab	3
827-C, -D & -E, Cells 1 & 2	4

b. At least two persons shall be present in the area during all explosives processing or handling. At least one of those present shall be qualified for the specific job being done.

c. A temporary waiver of the personnel limits may be obtained with the approval of the Site 300 Chemistry Facility Manager and concurrence of the Hazards Control Safety Team Leader.

*Revised

G. PERSONNEL CONTROLS - cont'd

*2. General

*a. All personnel entering or leaving the area shall report to the area office and notify the Facility Manager or his alternate. If no one is in the office, contact with the operating crew shall be made by the intercom system. Otherwise, entrance is prohibited.

*b. All matches, cigarette lighters and spark-producing instruments shall be deposited in the receptacles provided at the entrance to the explosives work area.

c. Consumption of food and beverage is permitted in control rooms or offices only. Employees shall wash their hands thoroughly before and after eating.

*d. LLNL issued shoes for contamination control shall be worn by all operating personnel. The Facility Manager will determine the shoe style to be issued and worn by all operating personnel. Consideration will be given to contamination control, sole attachment method and slip resistance. Plastic booties shall be worn by visitors not wearing LLNL issued shoes when the Chemistry Representative or alternate determines there is a possibility of H.E. contamination.

e. Safety glasses or other eye protection shall be worn by all personnel in all explosives processing areas and the general purpose machine shop in Building 827-B.

f. A list of authorized persons who may draw entrance keys shall be maintained by the Protective Force Department.

g. Metal objects, i.e., jewelry, coins, keys and tools, that could accidentally enter process equipment should not be carried into process bays or cells. Any keys or tools required should be carried in hip pockets.

h. Process water or wastewater containing solvents or oil are not allowed in the 4,000-gallon retention tank. Disposal of such water must be handled through Hazardous Waste Management.

*Revised

G. PERSONNEL CONTROLS - cont'd

3. Use of Personnel Alarms for Working Alone

a. Policy and guidelines for working alone are given in Procedure No. 130.

b. Those who qualify to work alone in the 827 Complex shall obtain a personnel alarm from the Chemistry Representative or alternate and wear it at all times.

c. The alarm shall be tested when the person arrives at his work area. Thereafter, the person shall activate his alarm only if he requires emergency assistance.

d. An audible alarm and a location indicator panel in 827-A will alert and direct personnel in the 827 Complex to the emergency area.

e. The personnel alarm shall be returned to the Chemistry Representative or alternate at the end of each day.

*H. EMERGENCY ACTION

The action to be taken in an emergency is defined in the Site 300 Safety and Operational Manual, Section E. All personnel working in the Chemistry Area shall be familiar with this procedure prior to working in Buildings 825, 826 and the 827 Complex.

Any equipment malfunction or irregularity during the processing of explosives requires that the Site 300 Facility Manager and the Livermore EMS Leader and Hazards Control be notified of the malfunction or irregularity. The Operator-in-Charge will receive direction from one or all of the above and will proceed as directed.

*Revised

CHEMISTRY AREA OPERATING PROCEDURE
BUILDINGS 825, 826 AND 827 COMPLEX

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Site 300 Resident Manager

APPENDIX A

CLASSIFICATION OF ELECTRICAL INSTALLATIONS IN CHEMISTRY FACILITIES

Building		Classification	Division
821 -	No Explosives	1	2
825 -	Cell 1, Room 102	1	1
	Cell 2, Room 108	2	1
826 -	Cell 1, Room 102	1	1
	Cell 2, Room 108	1	1
827-C -	Cell 1, Room 101	1	1
	Cell 2, Room 105	1	1
	Vault, Room 103	1	1
827-D -	Cell 1, Room 101	1	1
	Cell 2, Room 105	1	1
	Vault, Room 103	1	1
827-E -	Cell 1, Room 101	1	1
	Cell 2, Room 105	2	1
	Vault, Room 103	1	1

Appendix G

Levels of Personal Protection

Appendix G

Levels of Personal Protection*

LEVEL A—To be selected when the greatest level of skin, respiratory, and eye protection is required.

Level A equipment; used as appropriate.

1. Pressure-demand, full face-piece self-contained breathing apparatus (SCBA), or pressure-demand supplied air respirator with escape SCBA, approved by the National Institute for Occupational Safety and Health (NIOSH).
2. Totally encapsulating chemical-protective suit.
3. Coveralls.*
4. Long underwear.*
5. Gloves, outer, chemical-resistant.
6. Gloves, inner, chemical-resistant.
7. Boots, chemical-resistant, steel toe and shank.
8. Hard hat (under suit).*
9. Disposable protective suit, gloves and boots (depending on suit construction, may be worn over totally encapsulating suit).
10. Two-way radios (worn inside encapsulating suit).

*Optional, as applicable.

LEVEL B—to be selected when the highest level of respiratory protection is necessary but a lesser level of skin protection is needed.

Level B equipment; used as appropriate.

1. Pressure-demand, full-facepiece self-contained breathing apparatus (SCBA), or pressure-demand supplied air respirator with escape SCBA (NIOSH approved).
2. Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls).
3. Coveralls.*
4. Gloves, outer, chemical-resistant.
5. Gloves, inner, chemical-resistant.
6. Boots, outer, chemical-resistant, steel toe and shank.
7. Boots-covers, outer, chemical-resistant (disposable).*
8. Hard hat.
9. Two-way radios (worn inside encapsulating suit).

10. Face shield.*

*Optional, as applicable.

LEVEL C—To be used when the concentration(s) and type(s) of airborne substance(s) are known and the criteria for using air purifying respirators are met.

Level C equipment; used as appropriate.

1. Full-face or half-mask, air purifying, canister equipped respirators (NIOSH approved).
2. Hooded chemical-resistant clothing (overalls; two-piece chemical-splash suit; disposable chemical-resistant overalls).
3. Coveralls.*
4. Gloves, outer, chemical-resistant.
5. Gloves, inner, chemical-resistant.
6. Boots, outer, chemical-resistant steel toe and shank.*
7. Boots-covers, outer, chemical-resistant (disposable).
8. Hard hat.
9. Escape mask.*
10. Two-way radios (worn under outside protective clothing).
11. Face shield.*

*Optional, as applicable.

LEVEL D—A work uniform affording minimal protection; used for nuisance contamination only.

Level D equipment; used as appropriate.

1. Coveralls.
2. Gloves.*
3. Boots/shoes, chemical-resistant, steel toe and shank.
4. Boots, outer, chemical-resistant (disposable).
5. Safety glasses or chemical splash goggles.*
6. Hard hat.
7. Escape mask.*
8. Face shield.*

*Optional, as applicable.

The types of hazards for which levels A, B, C, and D protection are appropriate are described below:

Level A protection should be used when:

1. the hazardous substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system based on either the measured (or potential for) high concentration of atmospheric vapors, gases, or particulates; or the site operations and work functions involve a high potential for splash, immersion, or exposure to unexpected vapors, gases, or particulates of materials that are harmful to skin or capable of being absorbed through the intact skin.
2. Substances with a high degree of hazard to the skin are known or suspected to be present, and skin contact is possible, or
3. Operations must be conducted in confined, poorly ventilated areas and the absence of conditions requiring Level A have not yet been determined.

Level B protection should be used when:

1. The type and atmospheric concentration of substances have been identified and require a high level of respiratory protection, but less skin protection.

NOTE: This involves atmospheres with IDLH concentrations of specific substances that do not represent a severe skin hazard; or that do not meet the criteria for use of air-purifying respirators.

2. The atmosphere contains less that 19.5 percent oxygen, or
3. The presence of incompletely identified vapors or gases is indicated by a direct-reading organic vapor detection instrument, but vapors and gases are not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the intact skin.

Level C protection should be used when:

1. The atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect, or be absorbed through, any exposed skin.
2. The types of air contaminants have been identified, concentrations measured, and a canister respirator is available that can remove the contaminants, and
3. All criteria for the use of air-purifying respirators are met.

Level D protection should be used when:

1. The atmosphere contains no hazards, and
2. Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

NOTE: As stated before, combinations of personal protection equipment other than those described for Levels A, B, C, and D protection may be more appropriate and may be used to provide the proper level of protection.

**This information is from 29 CFR 1910.120 Appendix B.

Appendix H

Example of an Operational Safety Procedure for ERD Site 300 Section Field Operations

OFFICIAL COPY

GROUND WATER AND SOIL INVESTIGATION ACTIVITIES AT SITE 300 PIT 7 COMPLEX

1.0 Reason For Issue

This OSP serves as an administrative tool to summarize many of the requirements of the LLNL *Health & Safety Manual* which are pertinent to this operation and to discuss potential hazards and controls. This OSP supplements the existing Site 300 Environmental Restoration Site Safety Plan which addresses this work (UCRL-21172).

2.0 Work To Be Done And Location Of The Activity

2.1. Work to be done includes: borehole drilling with rotary, auger or other types of drill-rigs, drilling, development and installation of ground water monitor wells, soil, rock, ground water sampling and downhole geophysical measurements.

2.2 Location: B-Division Site 300 West Firing Area, Pit 7 Complex.

3.0 Responsibilities

3.1 M. J. Taffet (Ext. 2-6114) is responsible for the safety of this operation and for assuring that all work is performed in conformance with this OSP, and applicable sections in the LLNL *Health & Safety Manual, Environmental Protection Handbook,* the *Site Safety Plan for Site 300 Environmental Restoration* and the *Site 300 Safety and Operational Manual.* In the absence of M. J. Taffet, L. M. Kilmer (Ext. 3-5043) shall assume these responsibilities.

3.2 Any changes in operations that improve or do not significantly affect safety and environmental controls may be approved by the approving individual(s) for this OSP and the ES&H Team 1 Leader. The responsible individual shall ensure that this action is documented in a memorandum. Any changes in operations that increase the hazard level, introduce additional hazards, or decrease safety shall not be made until a revision of or supplement to this OSP has been reviewed and approved consistent with the review and approval process for the original OSP.

3.3 Before starting operations, and every six months thereafter, the responsible individual shall verify and document that the operating personnel have read and understand the OSP. (See attached, "Safety Procedure Communication form.")

4.0 Hazards Analysis

4.1 Drilling Operations:

Personnel working in and/or near drilling rigs are exposed to a variety of potential mechanical hazards including moving machinery, high pressure lines (e.g. hydraulic lines), falling objects, drilling through underground utilities, flying machinery parts, and unsafe walking and working surfaces. The consequences of accidents involving these physical hazards can range from minor injury to fatal injury.

4.2. Electrical:

Electric power is often supplied by gasoline or diesel engine generators. Working conditions may be wet and electrical shock with possible fatal consequences may occur. In addition, it is possible that drilling operations may encounter buried electrical utilities, potentially resulting in exposure to very high-voltages which could be fatal and/or initiate fires.

4.3 Underground Utilities:

Drilling operations may encounter buried utilities including gas and electrical lines. Drilling into electrical lines may potentially result in exposure to very high-voltages that could be fatal and/or initiate fires. Drilling into gas lines may potentially result in an explosion.

4.4 Material Handling:

Lifting and handling of heavy and bulky equipment and loading boxes onto and off of trucks is required. Physical injury, particularly back strain or crushing injuries, may occur as a result of these activities.

GROUND WATER AND SOIL INVESTIGATION ACTIVITIES AT SITE 300 PIT 7 COMPLEX

4.5 Contaminated Materials:

4.5.1 Drillers, geologists, samplers and support personnel may come in contact with sediments, rock, soil, ground water and drilling fluids which have been contaminated with varying concentrations of hazardous materials. Halogenated solvents, metals, and radionuclides which can be encountered may be carcinogenic or hazardous; repeated exposure to these materials by inhalation, ingestion, or skin absorption may increase the risk of developing cancer or other ailments.

4.5.2 Overexposure to halogenated solvents may result in central nervous system damage, liver damage, or adverse reproductive genetic effects. Skin contact with halogenated solvents can also de-fat the skin, resulting in localized irritation, skin cracking, and infections, a condition referred to as primary dermatitis. It is anticipated that the concentration of most of these contaminants in ground water, rock, soil, drilling fluids or sediments will be so low as not to pose an occupational exposure concern. However, there may be exceptions where exposure of the drilling crew could be significant.

4.5.3 Specifically, the major potential chemical and radiological hazards from this operation are trichloroethylene (TCE), beryllium, uranium, chloroform, and tritium.

GROUND WATER AND SOIL INVESTIGATION ACTIVITIES AT SITE 300 PIT 7 COMPLEX

4.5.3.1 Trichloroethylene (TCE)

Trichloroethylene is a central nervous system depressant and a mild irritant of the respiratory tract. Injury to the cardiovascular and gastrointestinal system and the liver and kidneys has been observed. Exposure to low concentrations can cause cardiac arrhythmia. Exposure to trichloroethylene causes intolerance to alcohol. The liquid can penetrate the skin and prolonged skin contact may cause dermatitis in the form of irritation and blister formation. Repeated contact with the hands has produced paralysis of the fingers. The 8-hour Threshold Limit Value (TLV) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) and adopted by LLNL is 50 ppm.

4.5.3.2 Beryllium (Be)

The routes of exposure to Beryllium include inhalation of the dust and fumes, skin contact and ingestion. The most significant route of exposure is inhalation. Beryllium can produce acute and chronic lung disease, which may be fatal. Skin irritation and sensitization are possible upon contact with the substance. Be is classified as a suspect human carcinogen. The federal OSHA PEL for Beryllium is 0.002 mg/m^3, based on an 8 hour TWA.

4.5.3.3 Uranium (U)

The routes of exposure to U include inhalation of the dust and fine particulate, skin contact and ingestion. The most significant route of exposure is inhalation. Target organs are skin, bone marrow, lymphatics, liver, kidneys, lungs and blood.

GROUND WATER AND SOIL INVESTIGATION ACTIVITIES AT SITE 300 PIT 7 COMPLEX

4.5.3.4 Chloroform (Trichloromethane)

Chloroform is a central nervous system depressant that is toxic to the liver and kidneys. Its former use as an anesthetic has been discontinued due to the frequency of cardiac arrest and delayed hepatic injury. High concentrations can cause dizziness, nausea and delayed fatigue. The hepatotoxicity of chlorinated solvents can be potentiated by aliphatic alcohol's. Chloroform splashed in the eye can cause burning pain and corneal damage. Chloroform can also promote dermatitis by removing essential oils and fats from the skin. Chloroform is an animal carcinogen and may be a human carcinogen. The 8-hour TLV recommended by the ACGIH and adopted by LLNL is 10 ppm.

4.5.3.5 Tritium (^{3}H)

The routes of exposure from tritium include inhalation and dermal contact with, or ingestion of, tritiated water. The maximum detected activity of tritium in soil moisture or ground water in the study area is 7,000,000 pCi/L. At much higher activities, tritiated water exposure can cause blood disorders and damage to the central nervous system, reproductive system and eyes.

4.6 Noise:

Drilling equipment is capable of producing sound levels in excess of 85 dBA, the 8-hour Threshold Limit Value recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) and adopted by LLNL.

4.7 Drill Movement:

There is potential to strike personnel, buildings or other objects when maneuvering drilling rigs.

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4.8 Heat Stress:

The use of Tyvek coveralls significantly increases the potential for drilling and support personnel to experience heat stress. Adverse effects from heat stress include heat cramps, dehydration, skin rash, heat edema, heat exhaustion, heat stroke or death.

4.9 Explosives:

4.9.1 Personnel working or transiting Site 300 Firing Area may be exposed to explosives blast and fragment hazards if personnel perform duties within firing danger zones or other potentially hazardous distances (intraline quantity-distance) of explosives facilities.

4.9.2 Injuries and fatalities from blast or fragments can occur to personnel working in or transiting the Site 300 Firing Area who are not adequately protected during intentional initiation of explosives. Severity of injuries will be dependent upon degree of protection afforded and the distance the personnel are from the explosives at the time of the initiation.

5.0 Controls

The hazards listed in Section 4.0 are addressed in the LLNL *Health & Safety Manual,* the Environmental Restoration Project Standard Operating Procedures and the Site Safety Plan for Site 300 Environmental Restoration. Personnel involved in drilling operations shall be familiar with these documents before work begins so that each worker understands the portions of the documents pertaining to the particular operation.

The Site Safety Officer shall be responsible for safe working conditions and shall halt work if site conditions are deemed unsafe. Drilling operations shall not resume until the unsafe drilling conditions have been corrected. In addition, a daily safety meeting shall be conducted prior to the commencement of drilling operations to highlight specific safety concerns particular to the day's operations. Each safety meeting shall be documented as to topics discussed and personnel in attendance.

Each operation shall be conducted in accordance with the Laboratory's "Working Alone" policy as defined in the LLNL *Health & Safety Manual,* Section 26.15. In the event that it is necessary for individuals to work alone under any circumstance, the Site Safety Officer shall ensure that, at a minimum, adequate communications are maintained and that other persons are aware of the itinerary, intended work locations and estimated return time of the persons working alone.

Any equipment or materials left in the field unattended shall be turned off, secured and barricaded prior to leaving the site.

5.1 Drilling Operations:

5.1.1 An exclusion zone shall be clearly marked with barricades, signs, and/or taping (e.g., "Construction Area" tape) where only trained personnel associated with the drilling operations are permitted.

5.1.2 Open boreholes and wells shall be covered and/or secured when unattended, including during crew breaks.

5.1.3 At a minimum, workers are required to wear level D protective clothing, which includes hard hats, vinyl gloves, safety glasses, coveralls and steel toed safety shoes. Neoprene or nitrile rubber gloves shall be used when the potential for contact by immersion in liquids containing chlorinated solvents at more than 100 ppb exists (as determined in the field under the Environmental Restoration Division Standard Operating Procedures). The Site Safety Officer shall be responsible for the enforcement of personal protective clothing requirements.

5.1.4 Only trained operators shall be used for drilling operations. In addition, the safe use of drilling machinery shall be highlighted during the daily safety meeting. All hoses operating under pressure shall be securely tethered to prevent separation.

5.1.5 Workers required to climb drilling masts to perform maintenance and repairs shall be required to wear full-body harnesses and lanyards and be tied off throughout the process. All workers required to work on the mast of the drill rig shall be properly trained in the use of full-body harnesses and lanyards by their companies to conform with LLNL standards. The training shall be documented and auditable.

5.2 Electrical:

5.2.1 All electrical systems used during drilling operations shall be checked for proper grounding during the initial installation.

5.2.2 Where necessary (e.g., locations where workers are using electrical equipment around water or damp areas), Ground Fault Circuit Interrupters (GFIs) that trip at 5m A in 400 ms or less shall be used to protect workers from electrical shock.

5.3 Underground Utilities:

Prior to commencement of drilling, LLNL contractors shall locate underground utilities. If these utilities interfere with the drilling operation, then the LLNL designated Drilling Supervisor shall relocate the borehole to avoid any possibility of disrupting these utilities.

5.4 Material Handling:

5.4.1 Workers are instructed in safe handling and lifting practices. If any specialized lifting equipment such as forklifts are to be used, only trained operators shall be authorized to use such equipment.

5.4.2 Workers shall not push or pull a load that exceeds 600 lbs. (275 kgs.) alone.

5.4.3 Workers shall not manually lift objects that exceed 50 lbs. (23 kgs.) alone.

5.4.4 Materials and equipment handling evolutions shall be conducted in accordance with the LLNL *Health & Safety Manual*, Chapter 29 ("Material Handling").

5.5 Contaminated Materials:

5.5.1 The appropriate ES&H Technician and Environmental Analyst shall be notified prior to the commencement of any new drilling operations.

5.5.2 Clothing and equipment, including appropriate monitoring equipment suitable for the work conditions as specified by the ES&H Team 1, shall be made available and used as needed.

5.5.3 The Site Safety Officer or responsible individual shall monitor the breathing zone and drill cuttings with an Organic Vapor Meter (OVM) and/or an Organic Vapor Analyzer (OVA). If breathing zone concentrations recorded by field monitoring exceed twice background concentrations, or in the absence of background concentrations, 5 ppm, when measured using either an OVM or OVA or there is evidence of contamination that could impact worker health and safety, the Site Safety Officer shall request that drilling operations cease and contact the appropriate technical support personnel from ES&H Team 1. ES&H Team 1 personnel shall determine what additional controls are necessary prior to recommencing drilling.

The drill cuttings shall be surveyed using a GM detector equipped with an HP-210 probe and an LLNL Blue Alpha meter (supplied by the ES&H Team 1). If the radiation levels are twice background, the Site Safety Officer shall request that drilling operations cease and contact the appropriate technical support personnel from ES&H Team 1. ES&H Team 1 personnel shall determine what additional controls are necessary prior to recommencing drilling.

5.5.4 The drill hole and immediate area shall be kept moist throughout drilling, so as to prevent airborne dust. This shall be accomplished by spraying water from a tanker truck periodically. This control shall prevent inhalation of dusts containing beryllium and uranium.

5.6 Noise:

5.6.1 Whenever new or previously unevaluated drilling equipment is used, the drilling geologist shall contact ES&H Team 1 to obtain a noise survey. Noise survey results from previous borehole drilling operations indicate sound levels in excess of 85 dBA within approximately 50 feet of some auger and air drill rigs. A controlled area must be maintained at this distance around the drilling rig with a posting at each entrance to the controlled area to read:

CAUTION
NOISE HAZARD
Hearing Protection Required

5.6.2 Participation in a hearing conservation program is required for employees routinely exposed to noise levels exceeding 85 dBA. Visitors in the area for less than one hour may enter the controlled area without hearing protection.

5.7 Drill Movement:

The safe maneuvering of the drilling rig shall be addressed at the initial (and periodically thereafter) employee safety meeting.

5.8 Heat Stress:

5.8.1 The Site Safety Officer is responsible for monitoring employees for indications of heat stress. The ES&H Team 1 Industrial Hygienist shall perform heat stress measurements and provide heat stress control consultation.

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5.8.2 When heat stress conditions exist, the following must be made available:

- At least one large fan for direct air movement at the drillers work position as needed;
- A cool and shaded rest area;
- Regular rest breaks; and
- An adequate supply of drinking water.

5.9 Explosives:

5.9.1 Non-DOE facility personnel shall be restricted in their access to explosives areas. Normal entry to the Firing Area is controlled by the *Site 300 Safety and Operation Manual,* Procedure No. 300. In addition, for Site 300 drilling activities, a map (1" ≤ 200 ft.) of on-site drilling/work locations shall be submitted to Hazards Control Explosives Safety for evaluation prior to work. Explosives Safety shall evaluate the intended drilling/work locations to determine if they are within intraline quantity-distance of explosives locations or operations. For those locations within intraline distance, Explosives Safety shall determine if explosives must be removed from the locations during the course of the work or if the requirement may be waived. In the event the requirement is to be waived, the individuals cited in paragraph 3.1 are responsible for preparing the waiver and gaining approval.

5.9.2 All personnel working in or transiting the Site 300 Firing Area shall comply with the Mustering and Restricted Entry requirements of Procedure 300.

6.0 Environmental Concerns and Controls

6.1 Environmental Concerns

6.1.1 This operation will produce open boreholes, which may accumulate surface water and rain water thus resulting in potentially contaminated soil and ground water.

6.1.2 Drilling rig reservoirs containing fuel, hydraulic oil and engine coolant, may develop leaks which could result in soil and ground water contamination.

6.1.3 This operation will generate drilling debris, decontamination materials, discared safety equipment, and drilling mud and cuttings.

6.1.4 At Site 300, disruption of habitat of two endangered species, the San Joaquin kit fox (Vulpes macrotis mutica) and the large-flowered fiddleneck (Amsinckia grandiflora) could occur.

6.1.5 Site 300 contains sensitive historic and prehistoric areas.

6.2 Environmental Controls

6.2.1 Open boreholes, when not actively being drilled, shall be protected from surface water, rain water, (or other potentially contaminated fluids) to prevent soil and ground water contamination.

6.2.2 Fluids that have leaked from drilling rigs shall be contained, collected, placed in a waste container, and identified with the appropriate waste label. Typically, these fluids are managed with a disposable catch pan and absorbent materials and should be disposed of as drilling debris through Hazardous Waste Management.

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6.2.3 Drilling debris, decontamination materials, and discarded safety equipment shall be placed in separate containers labeled "Potentially Hazardous Waste-Pending Analysis" and stored at the Building 843 Waste Accumulation Area until analytical results are received. Any materials found to be contaminated shall be disposed of by the Hazardous Waste Management Division. Drilling mud and cuttings shall be disposed of according to Environmental Protection Department's Environmental Restoration Series Standard Operating Procedures for Site 300 dated February, 1993, (UCRL-MA-109115), Rev. 1.

6.2.4 Sixty days prior to the commencement of drilling, a survey shall be conducted to determine the presence or absence of kit fox dens and other state sensitive species and the type. No drilling shall be performed within 25 feet of a kit fox den at any time. Depending on the conclusions of the survey, additional monitoring or the establishment of exclusion zones may be required. No drilling activities shall be conducted which may endanger a population of large-flowered fiddleneck.

6.2.5 No drilling operations shall be conducted in identified historic or prehistoric sites at Site 300, and access to these sites shall be restricted by means of stakes, flagging, barricades, etc.

7.0 Training

7.1 All personnel who perform work under this OSP are required to attend HS-0095.

7.2 LLNL employee Supervisors are required to complete HS-4050, "Health Hazards Communication."

7.3 All LLNL employees routinely exposed to noise levels exceeding the ACGIH TLV and/or required to wear hearing protection on the work site shall complete HS-4360, "Noise."

GROUND WATER AND SOIL INVESTIGATION ACTIVITIES AT SITE 300 PIT 7 COMPLEX

7.4 All personnel who generate hazardous waste are required to attend the following Environmental Protection Department course (this course must be requested):

EP-0006 - "Hazardous Waste Generation and Certification"

It is permissible for personnel who have not attended the required course to work under the direction of a person who has completed the course for an interim period, not to exceed 90 days.

7.5 All LLNL employees utilizing fall protection equipment shall have completed HS-5960, "Fall Protection" within the past two years.

7.6 Contractors shall have equivalent training for the aforementioned courses provided through their companies.

7.7 Personnel involved shall have received at a minimum the 40 hours of CERCLA/SARA health and safety training pursuant to the requirements of 29 CFR Section 1910.120, and the annual 8 hour refresher course if applicable. Employees shall have completed 24 hours of supervised field training. Supervisors must also receive 8 hours of additional training as described in 29 CFR 1910.120.

7.8 The Responsible Individual shall ensure that all required training, including on-the-job training, if applicable, is complete and documented.

8.0 Maintenance

8.1 All field monitoring equipment shall be calibrated as specified in the Site 300 Site Safety Plan, LLNL Document Number UCRL-21172 dated October, 1989.

8.2 Drilling equipment shall be maintained by the drilling subcontractor.

9.0 Quality Assurance

Quality Assurance requirements are detailed in the Quality Assurance Project Plan, LLNL Site 300 Environmental Restoration Project, UCRL-AR-103160, Rev. 1.

GROUND WATER AND SOIL INVESTIGATION ACTIVITIES AT SITE 300 PIT 7 COMPLEX

10.0 Emergency Response Procedures

Contractors are responsible for providing first aid and medical assistance to their employees if they are injured or become ill. Emergency telephone numbers for Medical Assistance and the Fire Department shall be posted at each work site, i.e., 911 for Livermore and Site 300. All injuries and accidents shall be reported promptly to the Site Safety Officer or designated Drilling Supervisor. Hazards Control shall also be notified as soon as possible.

11.0 References

- Site Safety Plan for Site 300 Environmental Restoration UCRL 21172, October, 1989
- Environmental Restoration Division Quality Assurance Plan, Rev. 0, January 1994
- LLNL Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs) UCRL-MA-109115, Rev. 1, February, 1993
- Quality Assurance Project Plan Lawrence Livermore National Laboratory Site 300 Environmental Restoration Project, UCRL-AR-103160, Rev. 1, October, 1992
- LLNL *Health & Safety Manual*
- LLNL *Environmental Protection Handbook*
- *Standard Operating Procedures for Segregation of VOC Contaminated Drilling Spoils at LLNL Site 300*, prepared by Jack Gardner
- *Site 300 Safety and Operational Manual*

GROUND WATER AND SOIL INVESTIGATION ACTIVITIES AT SITE 300 PIT 7 COMPLEX

12.0 Review and Approval

Reviewed by: Michael J Taffet
M. J. TAFFET
Responsible Individual

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J. J. GRECI
Site 300 Safety Officer
Environmental Restoration Division

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Section Leader
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M L Grissom
M. L. GRISSOM
Site 300 Manager

GROUND WATER AND SOIL INVESTIGATION ACTIVITIES AT SITE 300 PIT 7 COMPLEX

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Lawrence Livermore National Laboratory
Operational Safety Procedure No. 300.44
Review Level C

Effective: 10/94
Expires: 10/95

GROUND WATER AND SOIL INVESTIGATION ACTIVITIES AT SITE 300 PIT 7 COMPLEX

SAFETY PROCEDURE COMMUNICATION FORM

This OSP has been read and reviewed by the following people on the dates indicated:

NAME (please print)	**INITIALS**	**EMPLOYEE NO.**	**DATE**

The Responsible Individual shall review and discuss this Safety Procedure every six months with all operating personnel. The Responsible Individual shall review and discuss this Safety Procedure with any new employee who will be performing work covered by it.

SIGNED:

Responsible Individual ____________________ Date ____________

NOTES:
- Responsible Individual shall ensure appropriate review, discussion, and documentation of OSP's
- A copy of this form shall be maintained in the appropriate facility file.

Appendix J

Appendix J.

Justification of Waiver of Federal Ground Water Monitoring Requirements

Justification of Waiver of Federal Ground Water Monitoring Requirements

We propose that ground water monitoring under 40 CFR 265.91 is not required for post-closure monitoring of the HE Open Burn Treatment Facility, based on the waiver described in 40 CFR 265.90(c). This appendix fulfills the requirement of a written demonstration that there is a low potential for migration of hazardous waste or hazardous waste constituents from the facility via the uppermost aquifer to water supply wells or to surface water.

The HE Open Burn Treatment Facility is not a landfill, and ash from the treatment of explosives waste and explosives-contaminated wastes was always removed to a final disposal location; therefore, only residual amounts of explosives contamination potentially remain in subsurface soil and rocks. Geology and hydrogeology of the area are described in detail in this document and will be summarized here as required by 40 CFR 265.90(c). Knowledge of the geology of Site 300 is based on the regional geologic mapping by Huey (1948), Raymond (1969), and Dibblee (1980a and b), supplemented by observations made during detailed hydrogeologic studies of portions of Site 300 conducted by LLNL in recent years (Raber and Carpenter, 1983; Carpenter *et al.*, 1983, 1986, and 1988; Buddemeier *et al.*, 1985; Taffet *et al.*, 1989; McIlvride *et al.*, 1990; and Crow and Lamarre, 1990). Site 300 is located within a series of steep canyons and hills mantled by Quaternary colluvium. Beneath the colluvium is bedrock composed of Pliocene continental sediments and Miocene to Cretaceous volcaniclastic rocks and marine strata. Alluvial deposits are locally present and are composed predominantly of terrace and flood plain deposits and ravine fills. Bedrock structure is complex, as several folds and minor faults exist beneath the site. Figure J-1 is a general geologic map of Site 300.

In order to develop a conceptual hydrogeologic model of Site 300, the stratigraphy, structure, geochemistry, hydrogeology, soil moisture, geomorphology, and physical characteristics of aquifers and aquitards within Site 300 were assessed through field mapping, drilling and monitoring well installation, and borehole geophysics. We also attempted to define aquifer permeabilities, preferred pathways of ground water flow, hydraulic barriers, and flow velocities, by conducting and analyzing numerous hydraulic tests, by evaluating flow paths as revealed by the presence of substances of environmental concern, and by analyzing the distribution of potentiometric heads. The resulting conceptual model also considers natural and anthropogenic water chemistry.

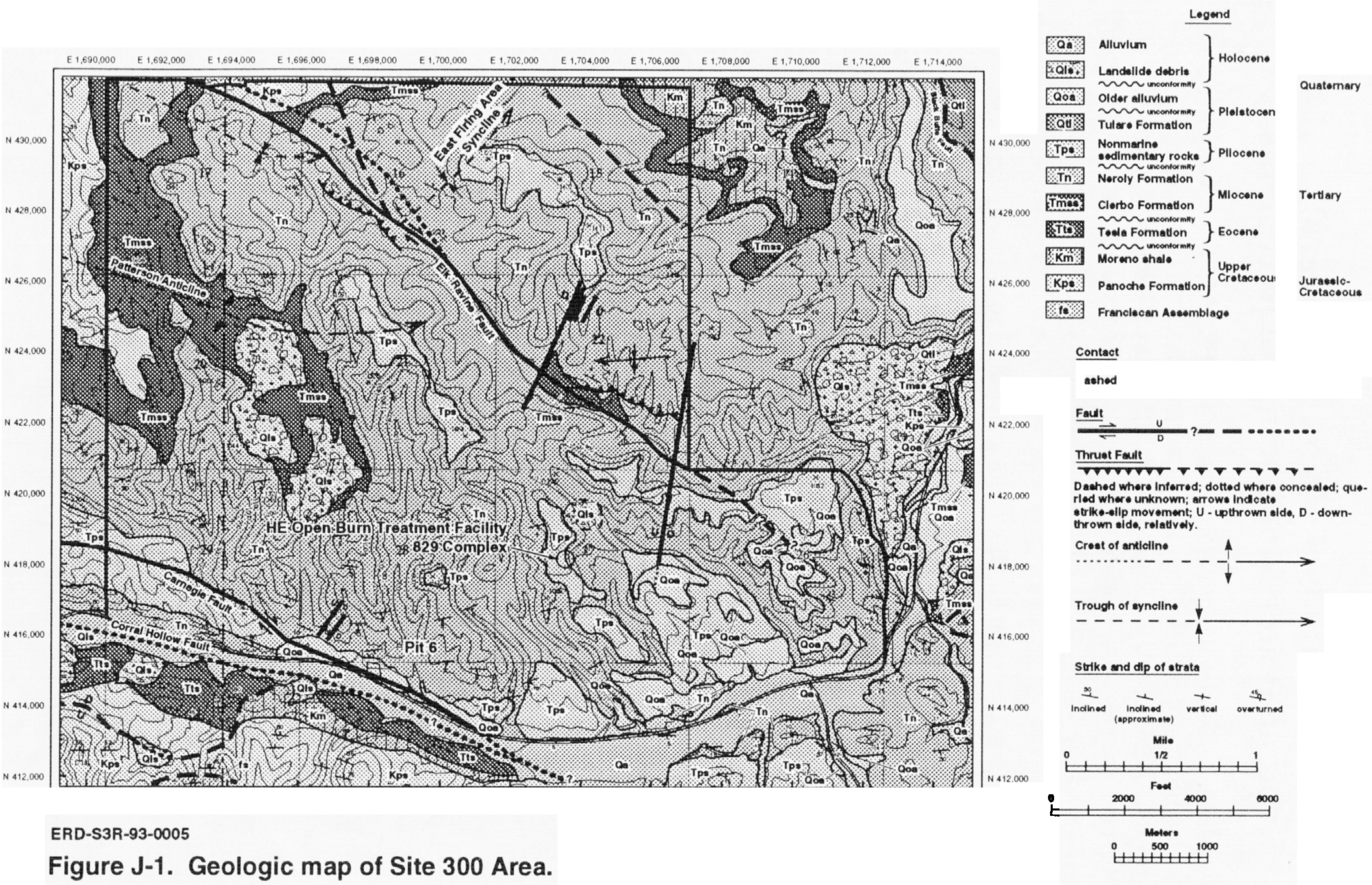

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Figure J-1. Geologic map of Site 300 Area.

Eight primary hydrologic units have been identified within Site 300. In order of increasing age and depth, the hydrologic units are:

- Quaternary terrace and alluvial deposits (Qa, Qoa)
- Pliocene nonmarine water-bearing zones (Tps)
- Neroly upper siltstone/claystone confining layer ($Tnsc_2$)
- Neroly upper sandstone aquifer ($Tnbs_2$)
- Neroly middle siltstone/claystone confining layer ($Tnsc_1$)
- Neroly lower sandstone water-supply aquifer ($Tnbs_1$)
- Cierbo claystone/siltstone/clayey sandstone aquitard (uppermost Tmss)
- Cierbo sandstone aquifer (Tmss).

The Cierbo Formation hydrologic units have been identified only in northerly portions of Site 300. Although we believe the Cierbo Formation (Tmss) occurs at depths beneath the HE Process Area study area, which includes the HE Open Burn Treatment Facility, it has not been encountered during drilling operations.

The principal aquifer within Site 300 is the Neroly Formation lower sandstone ($Tnbs_1$)water-supply aquifer. A potentiometric surface map for this aquifer as it occurs beneath the southeastern portion of Site 300 is shown on Figure J-2. Characteristics of this aquifer are variable within Site 300. In the southern portion of Site 300, above a deep claystone marker bed, this aquifer consists of several water-yielding zones separated by siltstone-claystone sequences that are believed to act as local aquitards. Hydraulic conditions range from unconfined and locally unsaturated in the north to artesian in the south. Drinking water production wells within Site 300 are completed in deeper portions of the $Tnbs_1$ aquifer that consist primarily of massive sandstone and conglomerate. This water is confined. In the southern portion of Site 300, ground water in the $Tnbs_1$ regional aquifer flows downdip to the southeast, controlled by the southward dip of the southern limb of the Patterson Anticline.

The HE Open Burn Treatment Facility is situated on the southwestern flank of the Patterson Anticline (Fig. J-1), immediately adjacent to a hilltop composed of remnant Pliocene nonmarine sedimentary rocks (Tps). The sedimentary beds on this limb of the anticline have a moderate southerly dip (±10°). Thicknesses of Tps strata remaining beneath the HE Open Burn Treatment Facility are generally less than 15 ft. The Neroly bedrock beneath includes complexly interbedded clay, sandstone, and fractured and weathered claystone with minor beds of gravelly and conglomeratic sandstone and siltstone (Webster-Scholten and Crow, 1989). Informal lithologic members $Tnbs_2$ and $Tnsc_1$ have been encountered in boreholes and wells drilled in the vicinity of the Open Burn Treatment Facility. $Tnbs_1$ strata are present beneath the facility at greater depths. Subsurface relationships at the facility site are shown on geologic cross-section A-A' (Fig. J-3). Subsurface geology from the facility downgradient to regional aquifer monitoring wells W-827-04 and W-827-05 is shown on geologic cross-section B-B' (Fig. J-4).

Precipitation in the area is low, averaging around 11 in. per year, and the potential evapotranspiration rate is high (60 in. per yr). Steep hills and rugged canyons contribute to a low infiltration rate, estimated at 10% of rainfall. Depth to the regional aquifer within the Neroly Formation lower blue sandstone unit (tnbs1) is almost 400 ft. From the HE Burn Pit facility, it is approximately 4,500 ft to the nearest facility fenceline and 6,140 ft to the nearest water supply (Lamarre *et al.*, 1993), and the ground water seepage velocity has been estimated at 250 ft/yr (Webster-Scholten, 1994).

The water balance, unsaturated zone and saturated zone characteristics, and distance to water supply wells demonstrate the low potential for migration of hazardous materials to the regional water-bearing zone and thus to water-supply wells, and the low potential for migration of these materials to surface water. Therefore the HE Open Burn Treatment Facility should not be subject to the ground water monitoring requirements of 40 CFR 265.91.

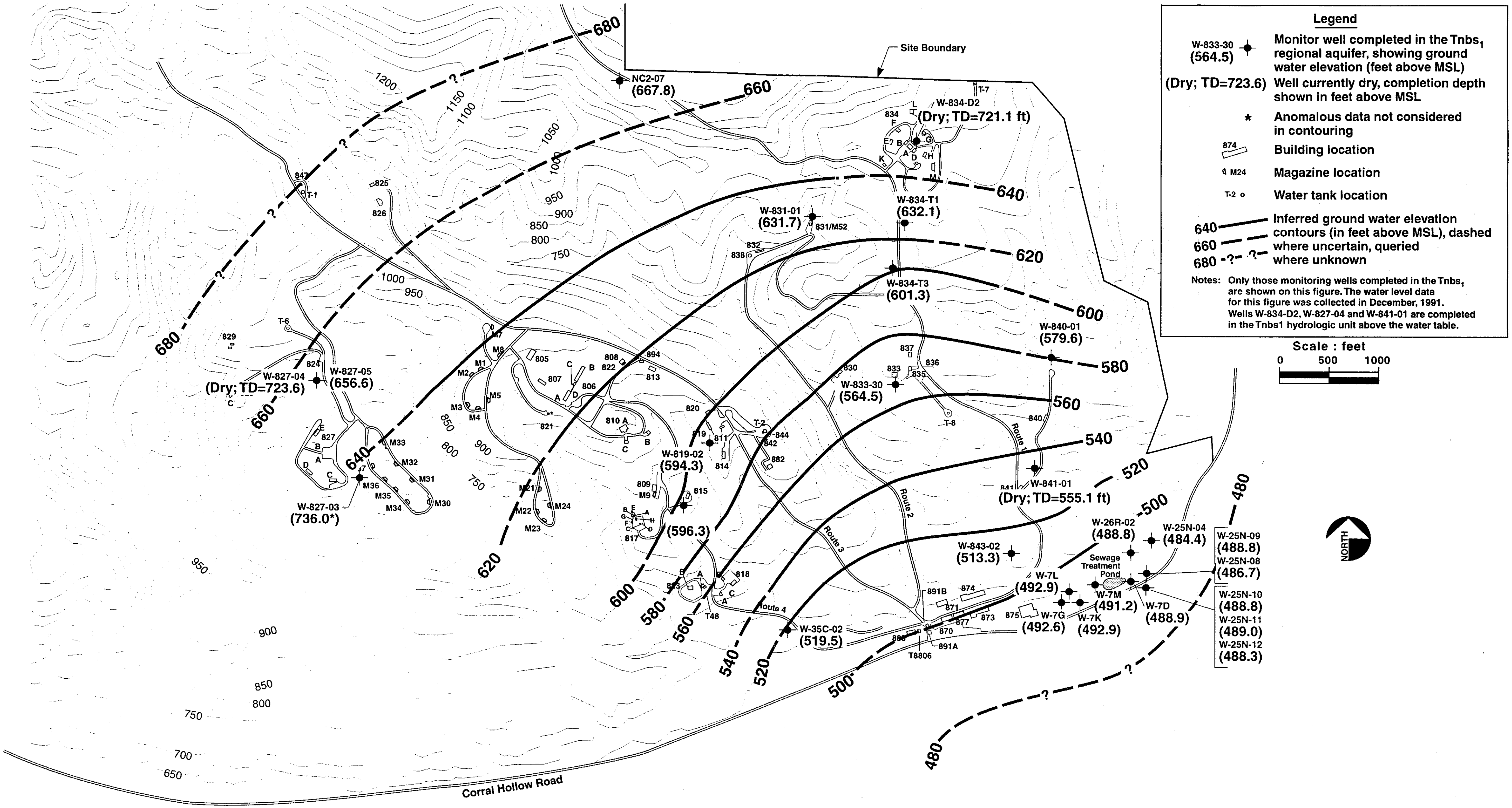
I certify that, to the best of my knowledge, the foregoing information is correct and was collected and interpreted under the direct supervision of a registered geologist. Additionally, the work was performed in accordance with professional standards.

REGISTERED GEOLOGIST
MICHAEL JEFFREY TAFFET
No. 5613
STATE OF CALIFORNIA

Michael J Taffet 4.23.97

Michael J. Taffet
Registered Geologist
No. 5616
License expires: May 31, 1997

Date



Notes: Only those monitoring wells completed in the Tnbs1 are shown on this figure. The water level data for this figure was collected in December, 1991. Wells W-834-D2, W-827-04 and W-841-01 are completed in the Tnbs1 hydrologic unit above the water table.

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Figure J-2. Potentiometric surface map of ground water in the Tnbs$_1$ regional aquifer in southeastern Site 300.

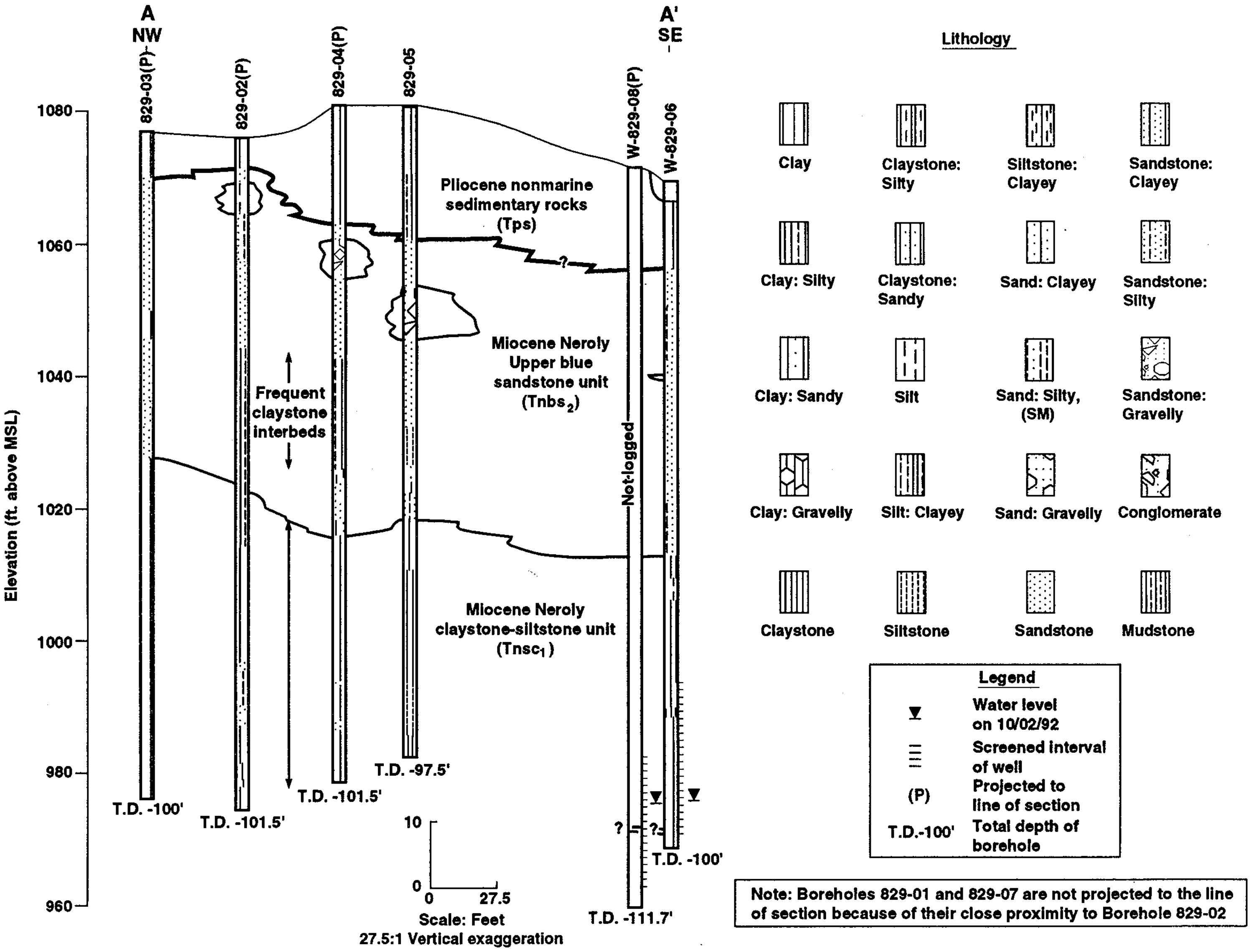

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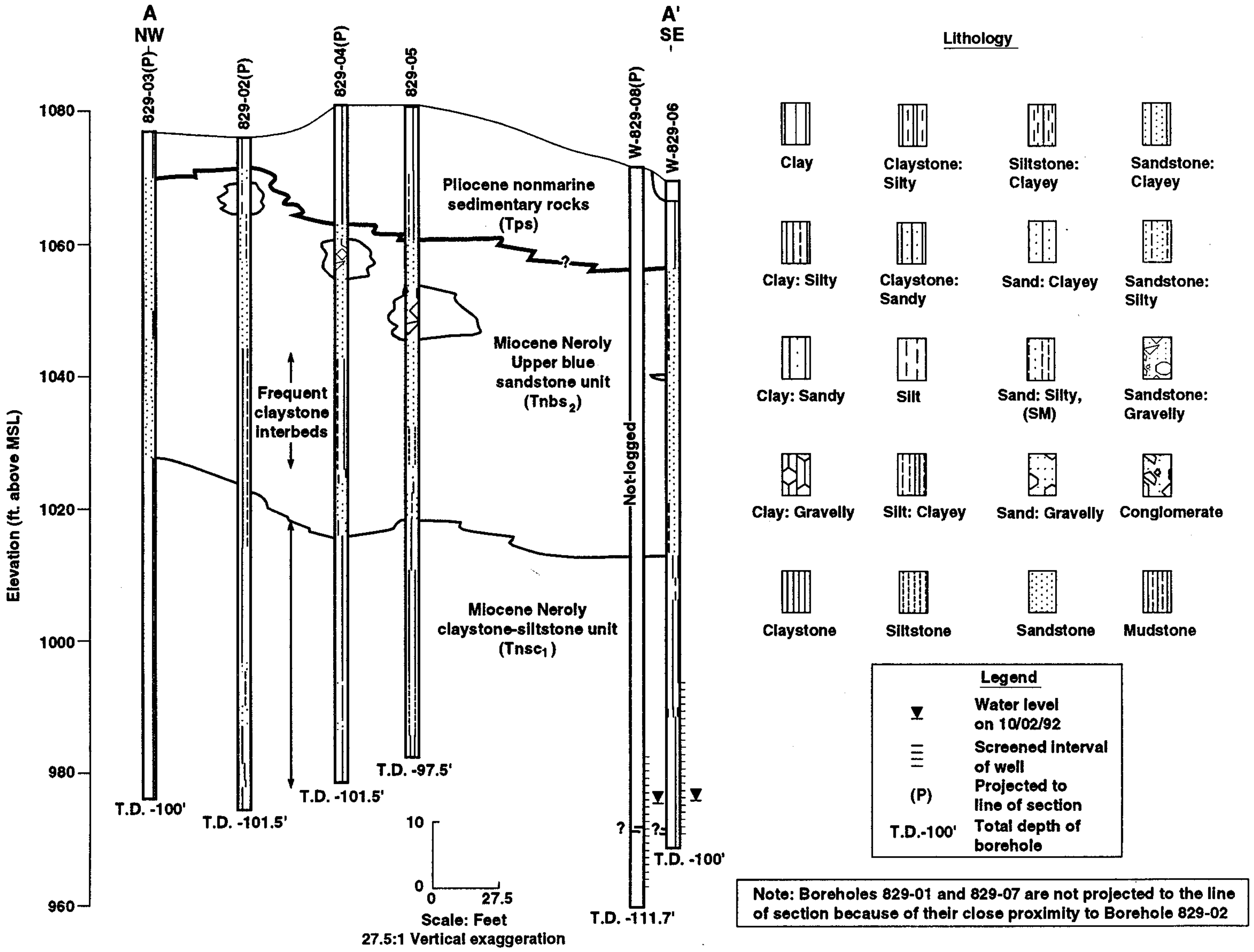
Figure J-3. Geologic cross-section A-A', Building 829 Complex, HE Open Burn Treatment Facility. Line of cross-section shown on Figure 1.2-4.



Note: Boreholes 829-01 and 829-07 are not projected to the line of section because of their close proximity to Borehole 829-02

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Figure J-3. Geologic cross-section A-A', Building 829 Complex, HE Open Burn Treatment Facility. Line of cross-section shown on Figure 1.2-4.

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